06

USARIEM TECHNICAL REPORT T06-[redacted]

PHYSIOLOGICAL AND COMFORT ASSESSMENTS OF VOLUNTEERS WEARING BATTLE-DRESS (BDU) UNIFORMS OF DIFFERENT FABRICS DURING INTERMITTENT EXERCISE

William R. Santee[1], Ph.D.
Larry G. Berglund[1], Ph.D.
Armand Cardello[2], Ph.D.
Carole A. Winterhalter[2]
Thomas L. Endrusick[1]

[1]Biophysics and Biomedical Modeling Division
U.S. Army Research Institute of Environmental Medicine

[2]U.S. Army Research, Development and Engineering Command
Natick Soldier Center

Natick, MA

JUNE 2006

U.S. Army Research Institute of Environmental Medicine
Natick, MA 01760-5007

DISCLAIMER

DTIC AVAILABILITY NOTICE

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE		PAGE
19	Ratings of “wet skin” sensation plotted over time (h) for each of the four garments, by environmental condition.	40
20	Ratings of “stickiness” sensation plotted over time (h) for each of the four garments, by environmental condition.	41
21	Ratings of garment “scratchiness” plotted over time (h) for each of the four garments, by environmental condition.	42
22	Ratings of perceived “softness” over time (h) for each of the four garments, by environmental condition.	43

LIST OF TABLES

BACKGROUND

The study of the biophysics of clothing properties and of clothing affecting the thermal responses of Soldiers falls under the USARIEM STO U: Fusion of Warfighter Performance, Environmental and Physiologic Models -- task B: Biophysical characteristics of the Warfighter. In addition, this study is relevant to a specific U.S. Army Research, Development and Engineering Command (RDECOM) project entitled Performance Criteria for Combat Uniform Materials. Project # 622786.

ACKNOWLEDGMENTS

The authors would like to thank the following individuals for their assistance during this study: Ms. Karen Speckman, Mr. Julio A. Gonzalez, Mr. Anthony Karis, SSG James R. Moulton, Ms. Laurie Blanchard, Ms. Jane Johnson, Mr. Adam DiChiara, and Ms. Kellie Zupkofska.

EXECUTIVE SUMMARY

Comfort is an important clothing property that is difficult to quantify. The overall purpose of the study described in this report was to develop and evaluate methods for quantifying the relationship between the physical properties of clothing worn at or near comfortable conditions to the wearer's physiological and subjective responses. The scope of the report includes a description of the overall study design, and results for the measurement of physiological and skin clothing friction measurements, and the subjective comfort responses to the test conditions. The purpose of this report is to document the study design, measurement and analysis of subject physiological responses, the skin/clothing friction testing, and the subjective sensory and comfort responses.

In this study, the sensory, affective (comfort related) and physiological responses of 9 Soldiers wearing Battledress Uniform style uniforms made of 4 different materials were quantified. The 4 combat uniform fabrics are currently in the military clothing inventories of the US, Canada, and Australia. They all have similar thermal insulation and water vapor transmission properties but differ in other ways. MIL-C-44436 is the standard combat uniform fabric used by U.S. military in hot and humid tropical environments and is a blend of 50% nylon (type 420, 1.7 denier per filament), and 50% combed cotton, in a ripstop poplin weave. MIL-C-43842 is the standard outer shell fabric used in US Army aviator clothing. The fabric is a blend of 92% Nomex, 5% Kevlar, and 3% other fiber. Australian Army specification 6557 is a blend of 50% cotton, and 50% polyester. Canadian National Defence specification D-80-001-098/SF-001 (1989-08-29) is a blend of 65% wool, and 35% polyester. The fabrics were specifically chosen based on their physical performance characteristics as they relate to thermal and sensory comfort such as weight, surface tactility, and wickability.

There were two test environments: the neutral condition (NC) of 20°C (68°F) and 50% RH and a warm humid (WH) condition of 27°C (80.6°F) and 75% RH. Wind speed was 1.1 $m \cdot s^{-1}$ (2.5 mph) for both environments. In the test chamber, after an initial 10 min baseline, the Soldiers alternated walking on a treadmill at 1.34 $m \cdot s^{-1}$ (3 mph) for 30 minutes, then sitting for 10 min period. The cycle was repeated four times for a total chamber time of 170 min. Prior to entering the test chamber, during walking and while seated in the chambers, and after exiting the chambers, the Soldiers answered questionnaires regarding various subjective aspects of comfort, skin feel, and their perception of thermal conditions. While seated in the chambers, skin friction tests, which consisted of measuring the force required to pull a piece of fabric across a bare forearm, were performed. Pre- and post-test clothed and nude body mass, and water consumption were recorded. The clothing was weighed separately before and after testing to determine water retention. During testing, relative humidity (RH_{uc}), and skin temperature (T_{sk}) were measured under clothing at 3 sites, and rectal temperature (T_{re}) was recorded every min. Heart rate was taken every 10 min. Body temperature (T_b) was calculated from T_{re} and mean T_{sk} ($\overline{T}_{sk}$), and skin wettedness (ω) was calculated from RH_{uc} and T_{sk}.

Physiological variables were compared statistically by environment (NC or WH). Although a few overall significant differences ($\alpha \leq 0.5$) for T_{re}, T_{sk}, T_b, RH_{uc} or ω, post hoc testing (Tukey's Studentized Range Test, $\alpha \leq 0.5$) indicated no significant differences

between any two garments. Results for sweating, water loss and retention in clothing for the NC (20°C) environment were not significant. For the WH (27°C) environment, differences for sweat retained in clothing (Sw_{cl}) were significant between the Canadian garment and each of the other 3 garments. For the rate of evaporative water loss (R_{ev}), the difference between the BDU and the Nomex garments was significant.

Skin friction was closely correlated to ω as moisture softens skin and increases drag or friction, thus requiring more force to pull it across wetted skin. Regression equations were calculated for each garment and environment to predict the skin friction coefficient (f) using ω as the independent variable. In the NC 20°C environment, when ω was uniformly low, there was no significant difference between garments. The friction test is most meaningful when the test environment produces enough stress to induce sweating and elevate skin moisture, a condition met in the WH environment. In that environment, R^2 values for the relationship between ω and f ranged by garment from 0.877 to 0.995. The skin friction test provided a simple, inexpensive method for comparing different clothing fabrics and determining the effects of skin moisture, which in turn may effect perceptions of comfort.

The subjective measures showed large overall differences between test environments. The ability to discriminate between materials was better in the WH environment, especially in terms of responses related to moisture. The effect of time on perception was only marginal in the control (NC) condition. In terms of skin contact, the wool blend Canadian fabric (C) was significantly worse than the other garments, and the somewhat stiff Nomex (D) also had poor skin contact sensations.

The results in this report indicate that without the sweating induced in the warm-humid (WH) environment, there were few significant differences in subject physiological responses between the test garments. Similar results were obtained for the skin friction tests. The results from the sensory and comfort related ratings indicate that the skin feel factors associated with the Canadian garment resulted in higher discomfort levels for this garment in both environments. Perceptions of comfort declined overtime in the chamber, with the effects being more pronounced in the WH condition. Given the lack of significant finding under the NC conditions, future testing could eliminate the NC treatment to more efficiently utilize resources.

This study allowed a comparison of methods for evaluating clothing comfort under carefully controlled laboratory conditions. The study findings indicate that both the skin friction test and the subjective ratings of skin feel and comfort sensations provide a means to clearly discriminate between clothing with similar thermal properties. It is thus likely that these methods could be applied under less controlled conditions, such as an outdoor test or exercise, with a degree of confidence that the tests would provide valid information regarding the relative performance of the different clothing materials.

INTRODUCTION

PURPOSE

The purpose of this study is to obtain data on the physiological and psychological responses of test Volunteers wearing Battledress Uniforms (BDU) made from permeable fabrics that differ in physical and sensory properties. These properties may influence the perception of thermal and tactile comfort sensations experienced by Soldiers while wearing these garments. The ultimate objective is to determine if these material properties can be used to predict the relative likelihood of acceptance of the combat uniform fabrics worn by Soldiers based on their perception of fabric and uniform comfort. This report covers the overall study design, and the results for the physiological measurements, the skin friction coefficient tests, and sensory and affective (comfort related) questionnaires. The study was funded by the U.S. Army Research, Development and Engineering Command (RDECOM).

A secondary test objective was to develop a reliable and valid quantitative method for comfort testing of BDU garments under minimal physiological strain. Once the methods have been developed, refined and validated in controlled studies, the methods may be used to collect data from larger populations under less controlled conditions. A new comfort test could result in significant cost-savings by identifying less expensive fabrics that provide an acceptable level of comfort.

Comfort has been identified as an important performance property of clothing materials, including fabrics. In military studies, comfort has been identified or defined primarily in the context of (1) a lack of discomfort, and (2) more specifically, the absence of thermal discomfort and physiological strain associated with thermally challenging environments and activities. Other variables that contribute to overall comfort, such as tactile sensations, have often been ignored or marginalized. In part this is due to the difficulty in separating thermal effects from other comfort factors during any simulation relevant to military activities. This study will focus on tactile comfort with moderate induced thermal strain, and an understanding of comfort and strain.

Thermal comfort is easier to define than overall psychological comfort as it may be related to more readily measurable physiological responses such as thermoneutrality or skin wettedness. For the classical definition of the thermal neutral zone (TNZ), an alert sedentary condition [resting metabolic rate - RMR] is specified. The borders of the TNZ are defined by an increase in metabolic cost above RMR for thermoregulation. Consequently conditions that encompass metabolic rates greater than RMR do not fit the classical definition of a TNZ. A working definition of neutral conditions (NC) for a given activity set is the range of environmental conditions under which there is no net metabolic cost increase for thermoregulation. Depending on circumstances, the relationship between thermal comfort and thermal neutrality is not a perfect fit. The comfort zone often extends beyond the boundaries of the NC to encompass moderate thermoregulatory responses such as light sweat. Given that comfort is a function of individual perception, moderate thermoregulation such as light sweating or a moderate decrease in skin temperature during a fast walk, expected responses during exercise, may be perceived as comfortable.

Clothing impacts the energy costs for thermoregulation by modifying the rate of heat transfer between an individual and his/her environment--thereby shifting the boundaries for NC.

The thermal state of an individual is determined by a combination of environmental exposure, and certain "personal" factors (Eissing, 1995) such as clothing, posture, activity level and internal physiology. Relative to an individual's thermal state, and ultimately Soldier readiness and mission performance, there are three levels of concern; comfort, function and survival. Comfort is a subjective condition determined by a combination of individual perception and approximate thermal neutrality. Comfort is often addressed from two perspectives – thermal comfort and the broader construct of psychological comfort. A condition of thermal discomfort precludes a perception of psychological comfort. The exception is when the activity presumes a degree of thermal strain. For example a jogger may perceive a warmer skin to be comfortable, whereas during a more sedentary activity by that same temperature would be considered uncomfortable by the same individual. Given that a degree of thermal strain is an anticipated and thus accepted factor in an activity, psychological discomfort may be more identified with clothing factors such as roughness or friction that may be controlled by clothing selection.

The functional zone includes the comfort zone. However, within the functional zone, there may be sufficient thermal stress to impact physiology (cause thermal strain). However, if individuals are able to compensate and still perform activities without significant impairment, they are, by definition, in the functional zone. The transition from function to survival occurs when the requirements for thermoregulation interfere with performance and/or body temperature ranges into hyper- or hypothermic zone. In the survival state, continued exposure is a threat to homeostasis. Deep body temperature is the best indicator of threat to survival, as thermal balance is the immediate concern for survival.

ASSESSMENT OF SENSORY and AFFECTIVE CLOTHING COMFORT

Procedures for assessing subjective aspects of thermal comfort are well established. Measures of thermal comfort involve individuals' assessment of the perceived effects of environmental variables, such as ambient air temperature (T_a) and relative humidity (RH). One of the most widely used subjective measures of thermal comfort is the McGinnis Thermal Scale (Hollies et al., 1979). This scale requires subjects to rate their thermal sensations on a 13-point scale ranging from "I am so cold, I am helpless" to "I am so hot, I am sick and nauseated". Another common thermal comfort scale is Gagge, Stolwijk and Hardy's (1967) Thermal Sensation Scale. The American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) thermal sensations 7-point scale, used in this study, is a widely accepted scale that evolved over long use. Elements of the ASHRAE scale have been incorporated into other thermal scales and comfort scales.

Sensations from the skin are believed to contribute to thermal comfort. Complementing and contributing to the thermal comfort scales, are tactile perception scales designed to assess the individuals' perceptions of garments. These are usually comprised of a series of discrete sensory attributes. One such scale is the Subjective

Comfort Rating Chart (Hollies, 1965), in which subjects rate the intensity of each of 15 tactile attributes arising from contact of garment fabrics against the skin, such as their stiffness, smoothness, snugness and clamminess. Other scales have been developed to measure the overall comfort or discomfort of an individual at any given moment. For example, Gagge et al.'s (1967) scale of comfort sensation enables individuals to evaluate their overall level of comfort or discomfort on a 4-point scale ranging from "comfortable" to "very uncomfortable". In general, most subjective measures of thermal comfort, skin contact sensation, or general affective comfort can be made specific to certain regions of the body, e.g. the face, back, hands and feet (e.g., Gonzalez, 1973; Marks and Gonzalez, 1974; Gonzalez & Nishi, 1976).

All of the above rating scales fall into the class of psychophysical scales known as "category scales". Although they have been used extensively to measure subjective comfort and skin contact variables, more sophisticated techniques have been developed. For example, in several studies examining the human sensory and comfort responses to clothing and textiles, magnitude estimation scaling has been successfully used as a measure of human sensory response (Gonzalez, 1973; Marks and Gonzalez, 1974; and Branson, 1990a; 1990b). This technique significantly increases the ability to accurately quantify subjective sensations by using a ratio level of measurement rather than an interval level. One practical problem, though, is that magnitude estimation requires perceptions to be directly compared to one another, thereby precluding judgments made over extended time periods. However, this practical limitation has been eliminated by the development of labeled magnitude scales. These scales commonly take the form of visual analogue or line scales, but they possess anchored verbal labels that define a ratio scale of sensory magnitude. The first such scale of this type was the Borg scale of perceived exertion (Borg, 1982). However, similar labeled ratio scales have been developed for judgments of taste and flavor (Green et al., 1993) and for overall liking/disliking (Schutz and Cardello, 2001). Recently, an affective labeled magnitude scale of clothing comfort (CALM) has been developed (Cardello, et al. 1998). This scale has been utilized in two chamber studies looking at the effect of water vapor permeability (MVTR) on clothing comfort. Results from these studies have shown that labeled magnitude scales of clothing comfort and skin sensation can be easily used by subjects to gauge their perceived bodily states.

The relationships between subjective measures of comfort, objective measures (e.g. physiological indicators), and fabric characteristics have been examined in several studies. Two physiological variables, skin temperature and skin wettedness, show the strongest associations with subjective comfort. In two laboratory studies, one examining subjects at rest (Gagge et al., 1967) and one examining subjects while exercising (Gagge et al., 1969), estimates of comfort and thermal sensation were found to be primarily related to changes in skin temperature caused by hot and cold environments. Markee et al. (1990) also found that skin temperature was a significant determinant of thermal comfort. In addition, in the Gagge et al. (1969) study, skin sweating was observed to be related to thermal discomfort. Yaglou and Rao (1947) and Vokac et al. (1971) reported similar results.

The popular method by Fanger (1972) to predict thermal sensations called Predicted Mean Vote or PMV uses the ASHRAE thermal sensations scale, which has 7-points ranging from hot (+3) to cold (-3) with a neutral (0) mid-point (ASHRAE, 1993).

Whole body thermal sensation depends on thermal physiological states (mainly T_{sk}, T_c) and may be predicted by energy balance methods for the activity, clothing and environmental conditions. Depending on the activity and environmental conditions the mean thermal sensation of the 7-point scale can be related to the clothing properties of thermal resistance (insulation) and water vapor permeability. Regression variables may include metabolism, temperature, clothing insulation, wind speed and humidity. In principle, the PMV method of thermal sensation prediction for steady state conditions is well recognized and widely accepted but some debate exists over its accuracy.

The relationship between subjective measures of comfort and garment fabric characteristics has also been examined. The subjects in Hollies et al.'s (1979) laboratory investigation could distinguish among jeans and shirts made from cotton, cotton-blended, and synthetic fabrics, using the sensory attributes included in the Subjective Comfort Ratings Chart (Hollies et al., 1979). In a study looking at the impact of fabric characteristics on evaluations of overall comfort, Mehrtens and McAlister (1962) found that fabrics with low scratchiness, resulting from fibers of less stiffness and friction, were high is perceived comfort. In addition, low fabric weight and low thickness led to better comfort, while wickability was unrelated to comfort. More recently, in a study of a wide range of fabrics used in military clothing (Cardello et al., 2003), the hand feel comfort of these fabrics was well predicted by a combination of sensory attributes related to the "surface texture and depth" of the fabrics, their "volume", and an auditory component.

The results of wear studies attempting to predict comfort from fabric characteristics have had less success. In Morris, Prato and White's (1984-85) examination of the determinants of user ratings of the comfort of socks, neither fiber content nor physical properties of the socks (e.g., weight, thickness, moisture absorption, air permeability, compressibility and compression resiliency) were significantly correlated with subjective evaluations. Comfort was affected only by the perceived softness of the socks and subjective estimates of foot dryness. Fuzek (1981) measured thermal transmittance and various moisture-related properties (equilibrium moisture content, water held between filaments, wickability, vapor water transfer) of t-shirts and found them to be only weakly related to subjective comfort. In contrast, garment fit, similarity to garments usually worn, perceived softness, and perceived surface smoothness showed the strongest relationships to comfort.

MILITARY RELEVANCE

Comfort is a subjective condition that is determined by a combination of individual perception and approximate thermal neutrality. Material factors such as the ability of the fabric to absorb perspiration and distribute it to a greater surface area, how heavy the fabric or garment feels, and such sensations as roughness or smoothness may also influence the wearer's subjective assessment of comfort, and ultimately the overall acceptability of the garment for wear in a particular situation. The BDU has been designed to provide a number of performance characteristics to improve the survivability of the Warfighter on the battlefield.

Comfort is subjective but it is also related to underlying physiological strains and sensory parameters and therefore predictable to a greater or lesser degree. To date the

biomedical modeling efforts have been primarily focused on physiological strain. The simultaneous subjective and physiological human response data from this study together with the fabric and clothing factors should enable general and specific algorithms to be developed relating subjective response to physiological and environmental parameters, particularly tactile type responses. The algorithms and subjective relationships when added to USARIEM thermo-physiological models will improve the completeness of our Warfighter simulation capabilities.

If a Soldier determines that the combat uniform is unacceptable due to comfort related factors, then the Soldier may, for example wear a t-shirt instead of the BDU jacket and not get the benefit of visual and near infrared camouflage protection, environmental protection such as solar radiation protection, and protection against cuts and scrapes on their elbows and upper torso. Military textile developers would benefit from the knowledge of which fabric parameters influence comfort so that they can manipulate these characteristics to ensure that new developmental combat uniform fabrics were acceptable for battlefield use.

Other potential aspects of military relevance include the effect of comfort on combat performance, cognitive performance, and morale. However, active combat represents a small percentage of Soldier time even during an active conflict. Most Soldiers spend a significantly longer period under garrison conditions, wearing the BDU as their work uniform. Under less threatening or stimulating conditions, tactile discomfort may become a significant distraction/factor shared by Soldiers of all ranks who wear the same uniform.

A considerable effort is made to instill in the U.S. Soldier a belief that the military, and by default the public, is providing the best available fabrics and equipment--weapons, food or clothing--to perform the specific mission and to ensure the individual Soldier's well-being. Through advertising and other product promotion, Soldiers are exposed to numerous claims regarding new and allegedly better equipment, and have little tolerance for what they perceive to be unnecessary discomfort. A perception of discomfort can lead to uncertainty regarding their importance, and public support, of their mission.

METHODS

VOLUNTEERS

Nine (9) healthy, 18 to 35-year-old Volunteers were recruited from the Natick Soldier Center and Human Research Volunteer Program to serve as test Volunteers. Prospective Volunteers were briefed on the study and expressly assured that they are completely free to withdraw from participation in the study at any time. After giving their written, informed consent, the Volunteers were medically screened before participating in the study. The purpose of the screening was to exclude individuals for whom the stress of the study may pose a greater hazard than for normal, healthy persons.

OVERVIEW

There were two test environments; a control condition of 20°C (68°F) and 50% RH and a WH condition of 27°C (80.6°F) and 75% RH. Wind speeds were 1.1 $m \cdot s^{-1}$ (2.5 mph) for both environments. Volunteers walked on a level treadmill at 1.34 $m \cdot s^{-1}$ (3 mph) for 30 minutes, then sat for a 10 min period. They provided responses to various questionnaires and sensations tests at various times throughout the test day. To minimize Volunteer risks and test costs, the test exposure and Volunteer exposure limits would have ended the test if Volunteers reach the threshold of mild hyperthermia as defined by a rectal temperature (T_{re}) of 38.5°C, as described in the health and safety section.

T_{re} and local skin wettedness (ω) on the skin surface were monitored. Thermal discomfort is often related to ω. A combination of warm air temperature, humidity and treadmill walking should induce sweating and elevate ω. Skin surfaces should remain drier under the control conditions, and skin to clothing friction or other tactile sensations should be the dominant factor. Skin surface temperature (T_{sk}), local RH under clothing, and heat flow (HF) were measured on the torso, thigh and forearm. Mean values were calculated using Burton's weighting of 0.50 for the torso, 0.36 for the thigh and 0.14 for the arm (Ramanathan, 1964). Body temperature (T_b) was calculated by weighting T_{re} by 0.9 and $\overline{T}_{sk}$ by 0.1.

Skin wettedness (ω) is defined as the ratio of the area of water-covered skin to the total skin surface area. It may be estimated from the actual vapor pressure difference across the clothing to the maximum if skin were completely wet (Berglund,1986):

$$\omega = (p_{uc} - p_a)/(p_{s,sk} - p_a)$$

Where the water vapor variables are the vapor pressure under clothing (p_{uc})), saturated vapor pressure at skin temperature ($p_{s,sk}$), and ambient vapor pressure (p_a). The vapor pressure under the clothing was calculated from the relative humidity and under clothing (RH_{uc}) and the saturated vapor pressure at temperature (T_{uc}) under clothing ($p_s(T_{uc})$):

$$p_{uc}=RH_{uc}\, p_s(T_{uc})$$

Given that the focus of this study is on comfort and clothing fabrics rather than on the evaluation of prototype military clothing, the area for the skin-to-clothing interface were increased by eliminating the t-shirt. A greater surface area should enhance the possibility of identifying differences in tactile responses associated with different fabrics. During testing the exact identity and properties of the different fabrics were withheld from the Volunteers. Ideally the test would have utilized a double-blind design, but some fabrics were only available in a single color or camouflage pattern.

SENSORY AND COMFORT-RELATED MEASURES

Each day after donning the garment, but prior to entering the test chamber, subjects completed a questionnaire designed to measure their perceptions of the sensory characteristics of the test garment fabric, the perceived fit of the garment and its overall comfort (Appendix A). In order to assess the effect of garment wear on these subjective variables, test subjects also completed a post-test questionnaire upon exiting the chamber at the conclusion of each day's test (Appendix B).

A battery of subjective sensory questions was used in two previous USARIEM protocols (BBMD94006-AP034-H026, HSP Log No. A-6947; H98-10, HSP Log No. A-8658) to assess subjective responses to clothing with varying water vapor permeability (MVTR)). Based on those results, a modified series of questions were developed. Subject responses to these sensory measures of clothing sensations and comfort were taken every 40 minutes throughout the duration of the test. Immediately prior to the start of the test and at 40-minute rest intervals throughout the test, rating scales of thermal comfort, clothing sensation and general affective comfort were administered to all subjects while seated (Appendix C). The comfort scale was the Comfort Affective Labeled Magnitude (CALM) scale (Cardello et al, 2003). In addition to a labeled magnitude scale of thermal sensation, the American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE) thermal sensations 7-point scale was used to allow a direct comparison to extensive data in ASHRAE literature. An additional series of questions concerning thermal status were administered during the walking phase of each work-rest cycle (Appendix D). During and after the tests, subjects were allowed to converse but could not discuss the questionnaires or their responses until the last test of the series was completed.

TEST CLOTHING

The test garments were made of a single design from fabrics that differ in physical properties. The garment design is the standard BDU as described in MIL-C-44048 Coats, Camouflage Pattern, Combat, and MIL-T-44047 Trousers, Camouflage Pattern, Combat. The 4 test fabrics are described in the following paragraphs. Garments were laundered 5 times prior to testing, and once between each test. Prior to a test day, garments for that day were hung overnight in a conditioning room at conditions of 29°C and 20% RH. To control for problems associated with fit, all Volunteers participated in fitting sessions to ensure the best possible fit within the limits of the prototype size tariff. The test garments were worn over biking shorts, running shoes, athletic socks and a hook and pile cuff which simulated the blousing of the trousers. The female test subject wore a sports bra. To

ensure uniformity, underwear and socks were provided for the Volunteers to wear every test day.

The four combat uniform fabrics are currently in the military clothing inventories of the US, Canada, and Australia. They all have similar thermal insulation and water vapor transmission properties but differ in other ways. The Australian Army specification 6557 (Uniform A), printed in the Australian camouflage pattern, is an oxford weave, and is made from a blend of 50% cotton, and 50% polyester. It weighs 5.1 ounces per square yard. MIL-C-44436 (Uniform B) is the standard combat uniform fabric used by U.S. military in hot and humid tropical environments. The fabric is Woodland camouflage printed, and is a blend of 50% nylon (type 420, 1.7 denier per filament), and 50% combed cotton, in a ripstop poplin weave. The fabric weighs 6.7 ounces per square yard. The Canadian National Defence specification D-80-001-098/SF-001 (1989-08-29) (Uniform C) is a solid green color, is woven in a plain weave, and is a blend of 65% wool, and 35% polyester, weighs 6.1 ounces per square yard. MIL-C-43842 (Uniform D) is the standard outer shell fabric used in US Army aviator clothing. The fabric is blend of 92% Nomex, 5% Kevlar, and 3% P140 electrostatic dissipative fiber, in an oxford weave, and is Woodland camouflage printed and water and oil repellent treated. The fabric weighs 7.1 ounces per square yard. The fabrics were specifically chosen based on their physical performance characteristics as they relate to comfort such as weight, surface tactility, and wickability.

Overall the fabrics weigh in the range of 6.1 to 7.1 ounces per square yard with the exception of the lighter Australian uniform. The Canadian fabric has demonstrated the least amount of perceived comfort in a previously conducted handfeel evaluation (Cardello et al., 2002). The Nomex Oxford has demonstrated the least wickability in several laboratory tests. The nylon/cotton ripstop is used as a "control" as it demonstrates the best attainable comfort while balancing other performance characteristics such as durability and camouflage effectiveness.

CLOTHING-SKIN FRICTION TEST

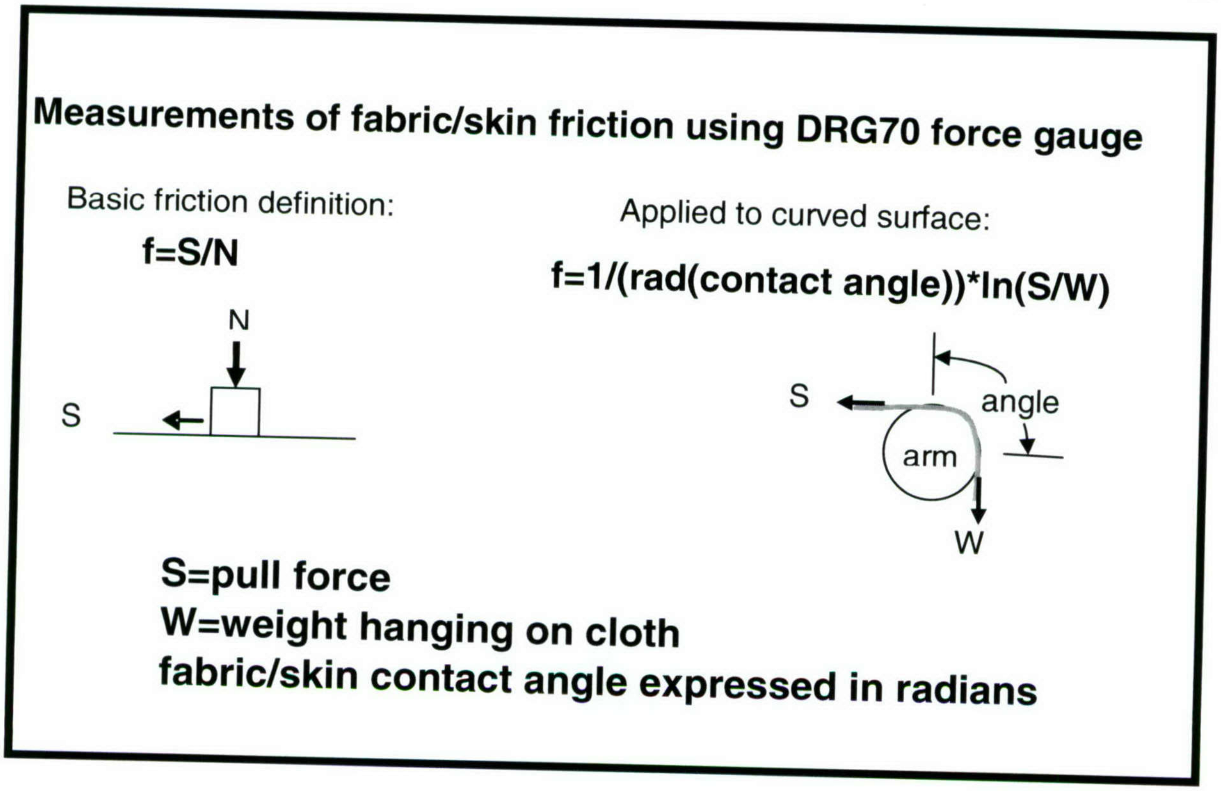
Prior studies (Gwosdow et al., 1986) have shown that friction increases with skin moisture. The BDU clothing test fabrics have different surface treatments, water absorption and other characteristics that may differentially affect friction between skin and fabric. To access this possibility and to broaden our understanding of clothing friction, the force required to pull the fabrics slowly across the volar surface of the bare forearm was measured on seated subjects.

The fabric pulled was the same fabric worn by the subject. The friction fabric, 9 cm wide and 26 cm long, had clamps placed on each of the narrower ends. A 100 g weight was hung from the lower clamp. The clamp at the upper end was attached to a digital force gauge (Omega DFG 70, Omega Engineering, Inc, Stamford, CT) held by the tester to measure the force. Figure 1 illustrates the basic theory and methodology of the test. The Volunteer extended his/her forearm, palm up, towards the tester, who pulled the cloth strip slowly across the bare skin with the gauge. The subject gripped an aluminum bar, so the arm was stationary. The maximum static force and average force to slide the fabric steadily across the skin were measured. The measurements were made before walking on the treadmill when the skin was dry and four times after treadmill walking when sweating

had begun. The friction measurement was repeated 3 times at each measurement interval. The test fabrics were in equilibrium with the test environment.

Body composition was estimated (Vogel et al., 1988) with the standard methods for determining body fat using body circumferences, height and weight (AR 600-9, June 1987). The body taping was conducted during the clothing study. The test site was the Doriot chamber located at the Natick Soldier Center. The complete protocol consisted of 8 days of garment testing in WH and NC environments.

FIGURE 1. Basic theory and methods for measuring the skin friction coefficient (f)



The fabric was the same as the Soldier was wearing. The forearm as shown was quickly uncovered just before the test. The force (S) to slowly and steadily slide the fabric across the skin was measured. Each test was the average of 3 pulls. Also measured and recoded was the contact length(CL) and circumference of arm (C), information to estimate the contact angle(see Figure 1) (CA):

$$CA=2\,\Pi\,CL/C \quad \text{radians}$$

To facilitate comparisons between fabrics and subjects and for other applications, the coefficient of friction (f) was calculated:

$$f=1/CA * \ln (S/W)$$

where W is weight hanging on fabric.

TEST SCENARIO

Pre-test: Subjects were weighed nude. Volunteers then inserted their rectal probe (YSI # 18480 flexible rectal probe with a 400 series (#44033) thermistor, Yellow Springs

Instruments, Yellow Springs, OH). A set of 3 heat flow discs (Concept Engineering Disk Heat Flux Transducer with Integral Thermistor, Model #: FR-025-TH44033-F6, Concept Engineering, Old Saybrook, CT) were placed on the back, arm, and thigh to measure mean weighted skin surface temperatures, and an anti-static ground were placed on the skin. Three (3) humidity sensors (Hy-Cal Humidity Sensor, Model #: IH-3602C, Honeywell International, Freeport, IL) were also be placed on the back, thigh, and arm. Volunteers then put on their heart rate monitor (Polar Beat, a "sports watch" heart rate monitor manufactured by Polar Electro Oy, Kempele, Finland) and continued to dress in an ensemble consisting of briefs, the test garment, running shoes and socks. Each day after donning the garment, but prior to beginning the test session, subjects completed a questionnaire designed to measure their perceptions of the sensory characteristics of the test garment, fit, and overall comfort (Appendix A). The fully clothed and instrumented Volunteers were weighed prior to entering the test chamber.

Chamber testing: On the morning of test days, the Volunteers entered the test chamber and were connected to the data acquisition system. They then sat on a bench for 10 min to complete a sensory questionnaire (Appendix B) before starting to walk. After walking for 30 minutes, the Volunteers sat again for 10 min and again answered the same questionnaire. There were four 30 min walking periods each followed by 10 min of sitting. During the walking segments, the Volunteers responded to a short thermal sensation questionnaire (Appendix C). During the initial baseline period, and during the resting periods, the clothing-skin friction test was administered. During each 10 min pause they were given 150 ml of water to drink. Volunteers remained in the chambers for a total of 170 min. They would have been removed from the chamber if they had reached the physiological limits selected for this study (specified in the Health and Safety Section), they voluntarily ended their participation, or they had been removed by the test observers or a medical officer due to other medical, safety or technical reasons.

Post-test measurements: Upon exiting the chamber, the Volunteers' post-exercise clothed weights were measured, then Volunteers sat and completed their final questionnaires (Appendix D). After undressing and removal of instrumentation they were weighed nude to obtain the post-exercise nude weight. Total water loss was determined from difference in pre and post nude weights plus weight of water drunk minus that excreted.

HEALTH AND SAFETY OF TEST VOLUNTEERS

The investigators have adhered to the policies for the protection of human subjects as prescribed in Army Regulation 70-25, and the research was conducted in adherence with the provisions of 45 CFR Part 46. As noted, Volunteers were medically screened before participating in the study to exclude those for whom the stress of a hot environment may pose a greater hazard than for normal, healthy persons. The Volunteers were expressly assured that they are completely free to withdraw from participation in the study at any time. Specific physiological limits for this study were a core temperature of 38.5°C (101.3°F) or a heart rate sustained for 1 min outside of the limits of 75 to 145 bpm for treadmill walking at 1.34 $m \cdot s^{-1}$ or above 100 bpm while seated.

RESULTS

SUBJECT POPULATION DESCRIPTORS

Population anthropometric variables (mean±sd) for the 9 subjects (1 female, 8 males) were age (23 ± 4 yr), height (174.2 ± 5.8 cm) and weight (73.4 ± 6.5 kg). Percent body fat was 17.90 ± 3.99%. Table 1 lists individual values.

Table 1. Subject population descriptors (n=9)

Subject	Age (yr)	Weight (kg)	Height (cm)	Body fat (%)
1	26	73.0	174.0	17.26
2	24	82.5	180.3	16.64
3	32	62.6	171.5	26.28
4	21	78.0	181.0	14.22
5	21	69.8	170.8	17.35
6	20	73.9	169.5	21.48
7	25	78.4	171.5	18.15
8	21	65.3	166.4	12.64
9	19	77.1	182.9	17.11
$\overline{X}$	23	73.4	174.2	17.90
SD	4	6.5	5.8	3.99

BIOPHYSICAL PROPERTIES OF THE CLOTHING

Manikin testing for total insulation (I_T in clo), water vapor permeability (i_m, ND) and an estimate of "cooling power" based on the ratio of i_m/clo^{-1} (ND) were derived from 3 test repetitions for each washed garment (Table 2). Based on t-tests, small, but significant differences (α=0.5) were found. The total insulation (I_T) for the Nomex (D) was significantly greater than the other three garments (A,B,C), and the wool (C) was greater than the Australian cotton (A). For water vapor peremability (i_m) and $i_m \cdot clo^{-1}$, the BDU (B) and wool (C) were significantly higher than Nomex (D). However, there is a difference between statistically significant differences and physiologically significant differences. Manikin test results are very replicable with very small variances. Consequently results from thermal manikins are frequently significant, but the actual differences are often quite small and have little real influence on subject responses. Based on an assumption (Santee and Blanchard, 2001) that a 10% difference in physical properties is required for a measurable difference on subject performance, i_m and the combined $i_m \cdot clo^{-1}$ variable are on the 10% boundary. Measured I_T values fell well below the 10% threshold, and are unlikely to have elicited different physiological responses.

TABLE 2. INSULATION and WATER VAPOR PERMEABILITY
(air speed =0.4 m/s)

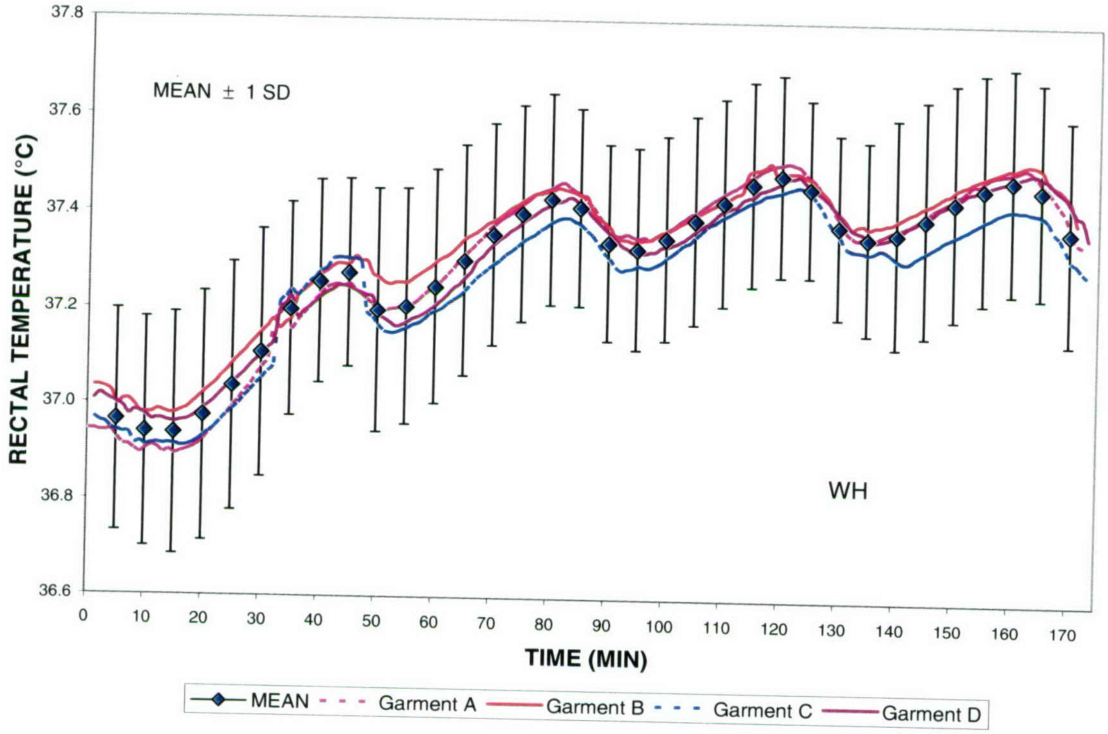
Uniform	Total Insulation (I_T)	Water vapor permeability index (I_m)	Cooling power (I_m/clo)	weight	Garment weight
	clo	ND	ND	oz·yd^{-2}	kg
Australian (A)	1.31	0.38	0.29	5.1	1.01
Light-weight BDU (B)	1.30	0.37	0.29	6.7	1.39
Canadian (C)	1.33	0.38	0.28	6.1	1.18
Nomex© (D)	1.34	0.35	0.26	7.1	1.42

PHYSIOLOGICAL RESULTS

Physiological Measurements: The physiological measurement made during the study of the changes in T_{re}, T_{sk}, humidity under clothing (%RHuc and ω), net water loss, evaporative water loss and sweat retention in clothing are summarized in Figures 2-10 and Tables 3 and 4.

Results for measurement of water loss and evaporation are presented in Figures 8-10 and Table 4. Values for sweating and evaporation were single values derived for the entire test period. The sweating efficiency (%EFF) is calculated as R_{ev}/R_w as a percentage. Net rate of water loss (R_w) is calculated as [(Pre-test nude weight + water) – (post-test nude weight)]/time in g/min. The rate of evaporative water loss (R_{ev}) is calculated as [(Pre-test dressed weight + water) – (post-test dressed weight)]/time in g/min. Both R_w and R_{ev} are presented in Figures 8 (NC) and 9 (WH). The value for sweat retained in clothing (SW_{cl}), in grams, is calculated from (Pre-test garment weight – post-test garment weight). Figure 10 presents values for SW_{cl} for the WH testing. Due to large variances (Table 4), data is not presented for NC.

Figure 2. Core (rectal) temperature under warm-humid (27°C, 75% RH) and neutral (20°C, 50% RH) conditions.



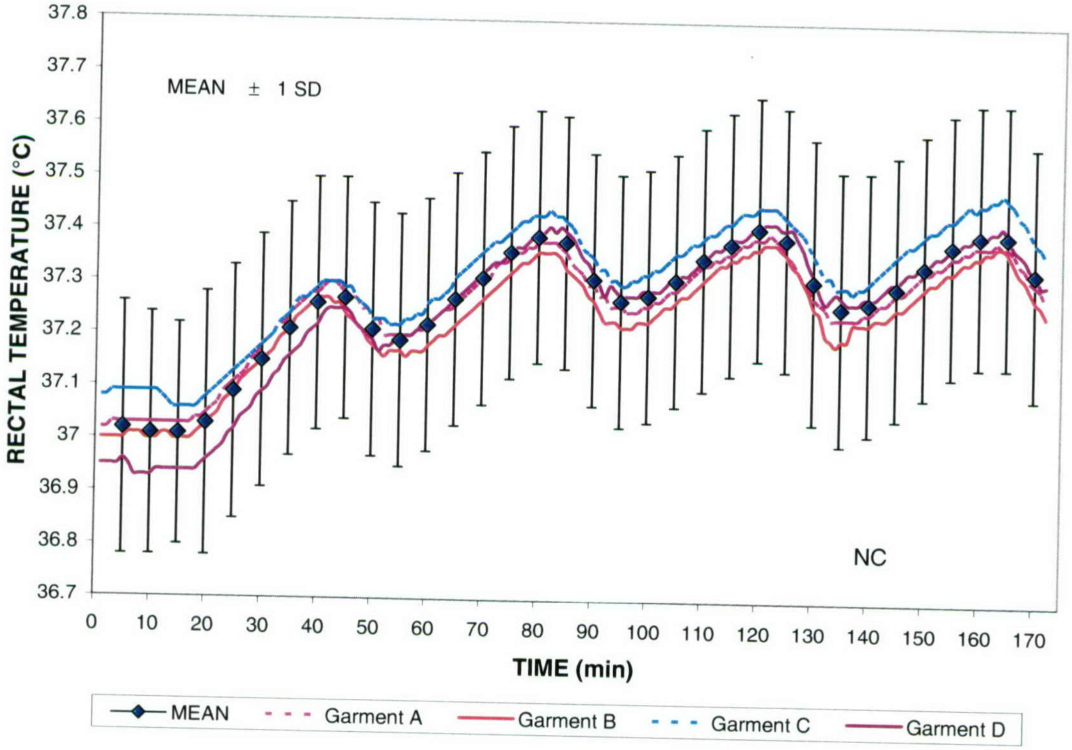
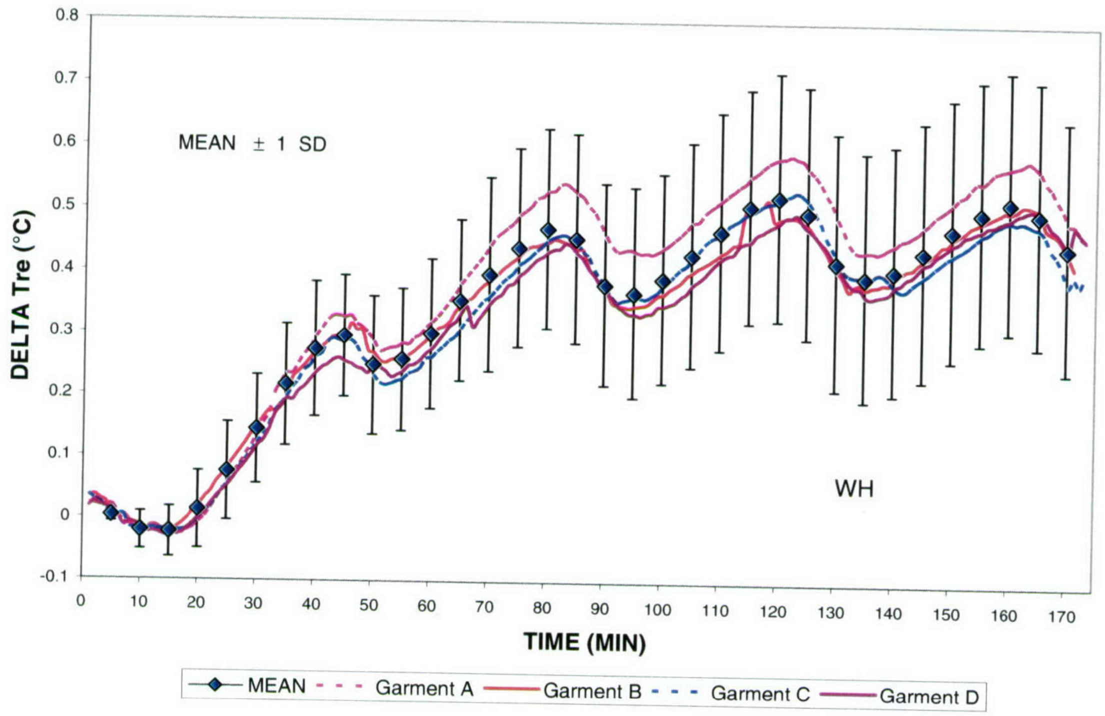


Figure 3. Changes in core temperature (DELTA T_{re}) under WARM-HUMID (27°C, 75% RH) and neutral (20°C, 50% RH) conditions.



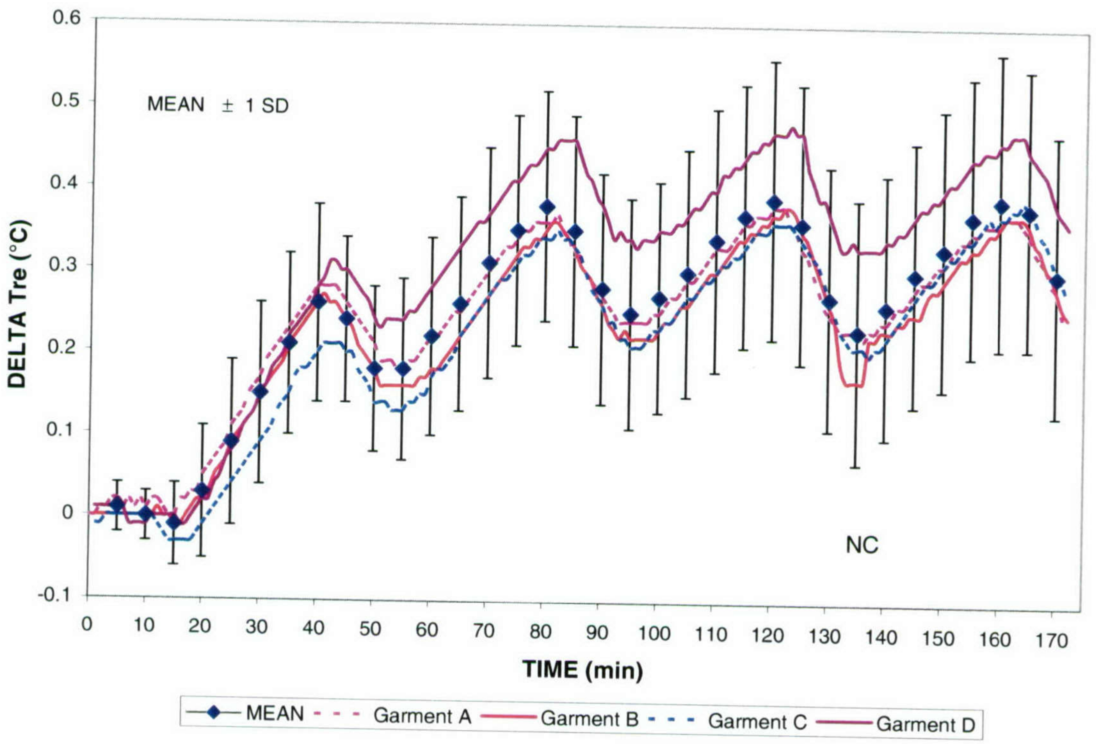


Figure 4. Mean body temperature ($\overline{T}_b$) under warm-humid (27°C, 75% RH) and neutral (20°C, 50% RH) conditions.

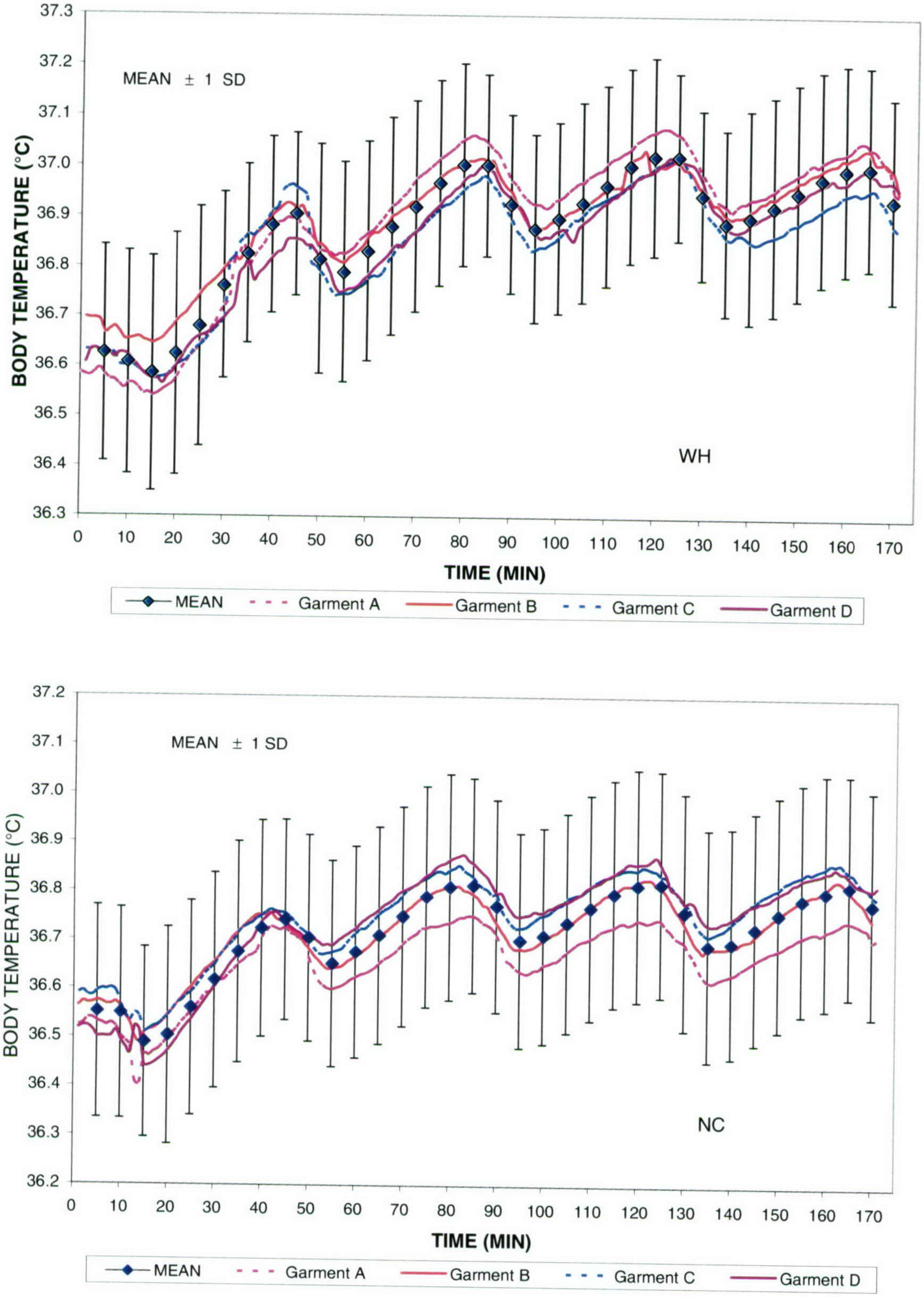


Figure 5. Mean skin temperature ($\overline{T}_{sk}$) under warm-humid (27°C, 75% RH) and neutral (20°C, 50% RH) conditions.

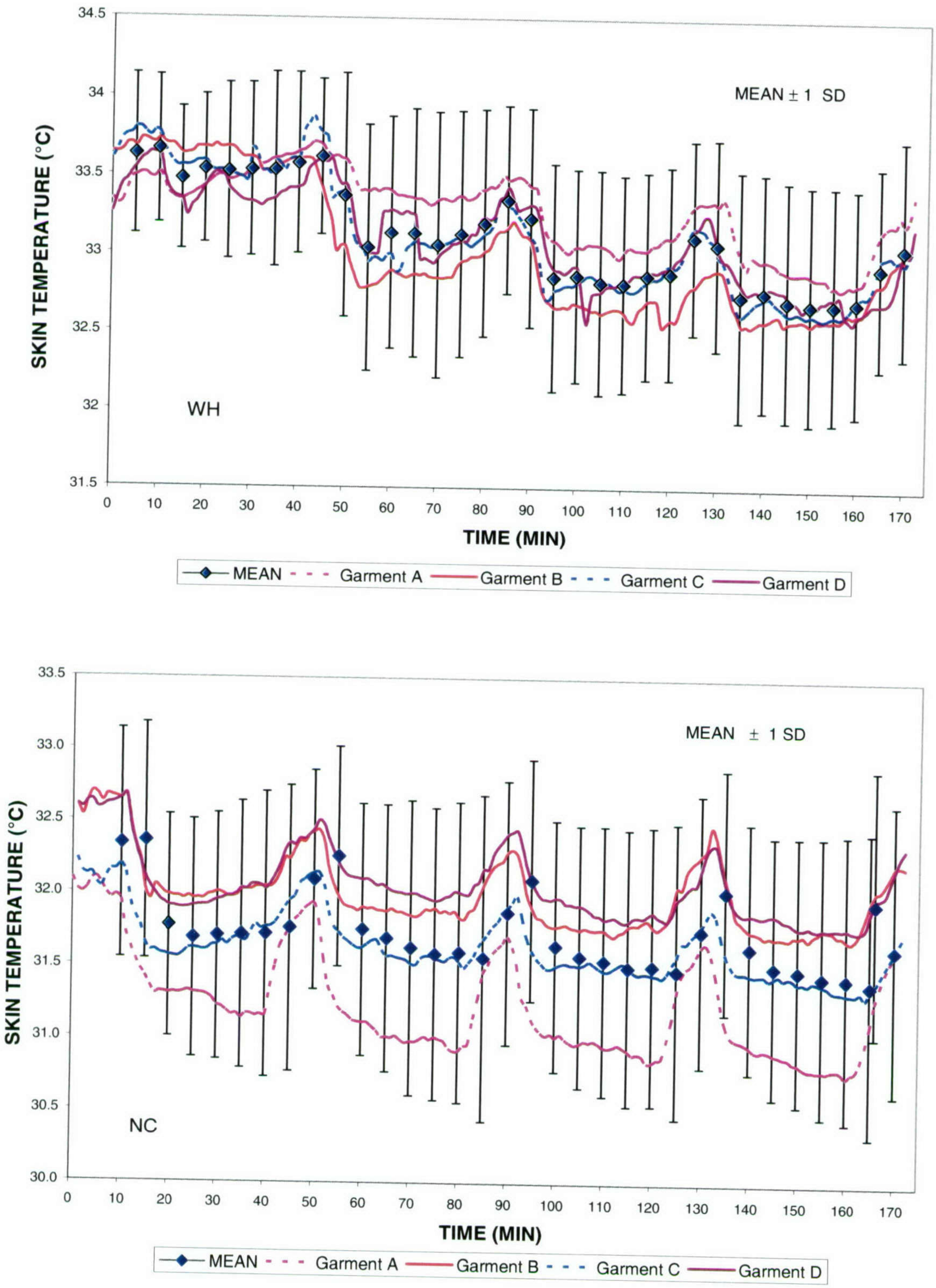


Figure 6. Mean relative humidity under clothing ($\overline{RH}_{uc}$) in warm-humid (27°C, 75% RH) and neutral (20°C, 50% RH) conditions.

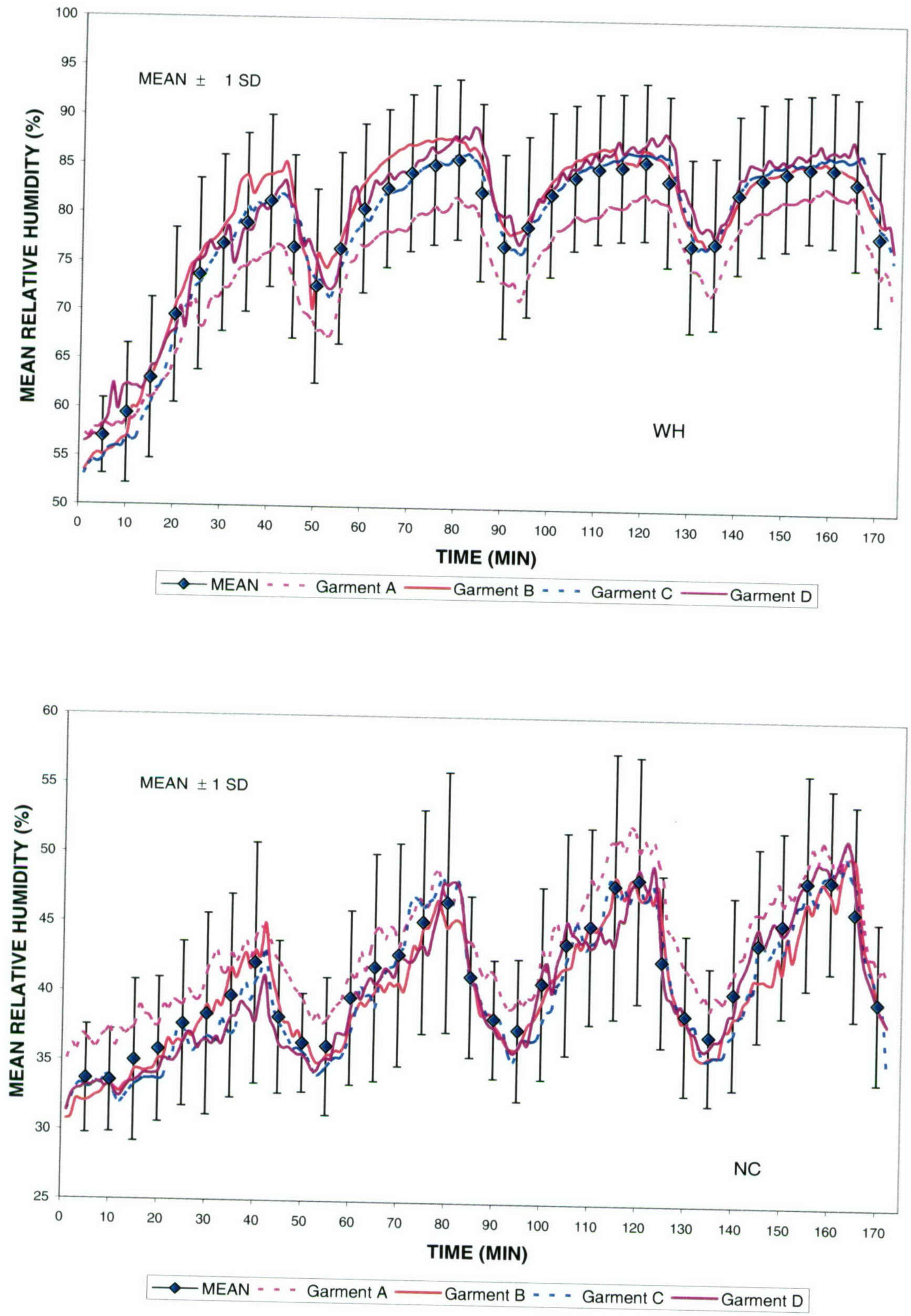


Figure 7. Mean skin wettedness (ϖ) under warm-humid (27°C, 75% RH) and neutral (20°C, 50% RH) conditions

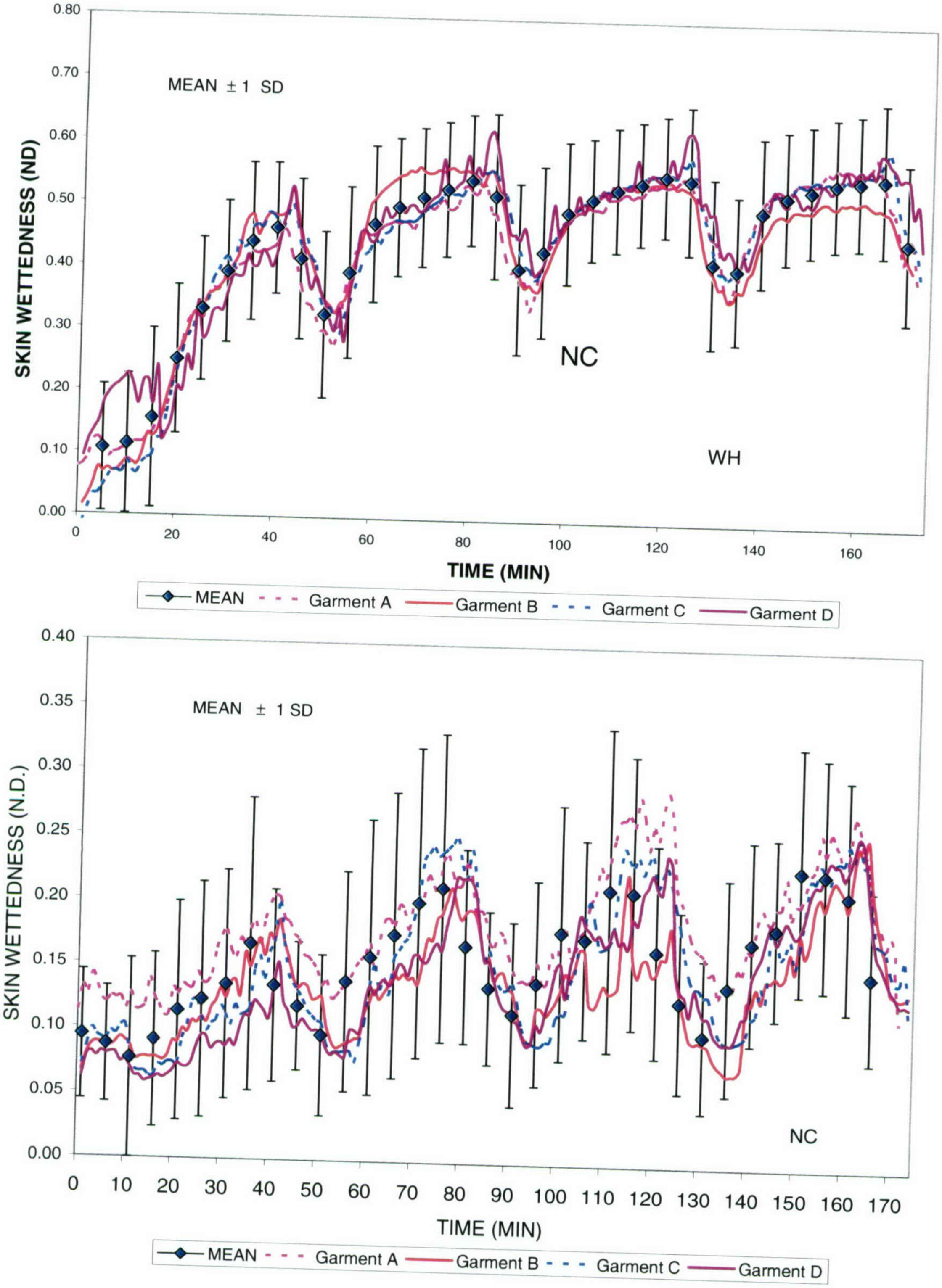


Figure 8. Net water loss (R_w) and evaporation (R_{ev}) under neutral (20°C, 50% RH) conditions.

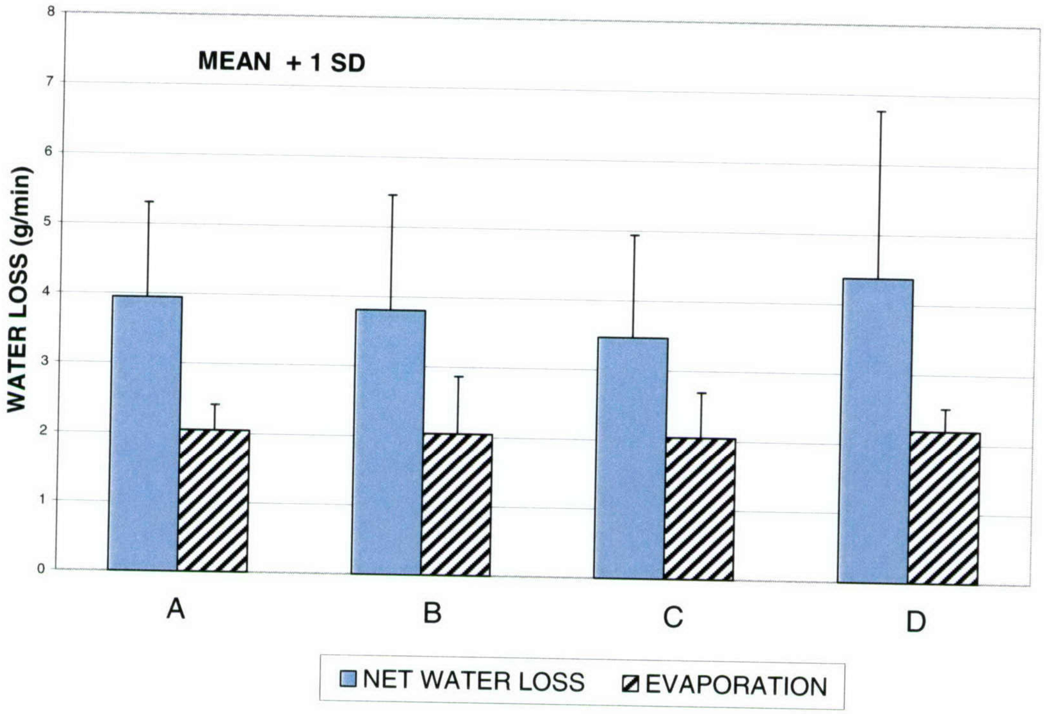


Figure 9. Net water loss (R_w) and evaporation (R_{ev}) under warm-humid (27°C, 75% RH) conditions.

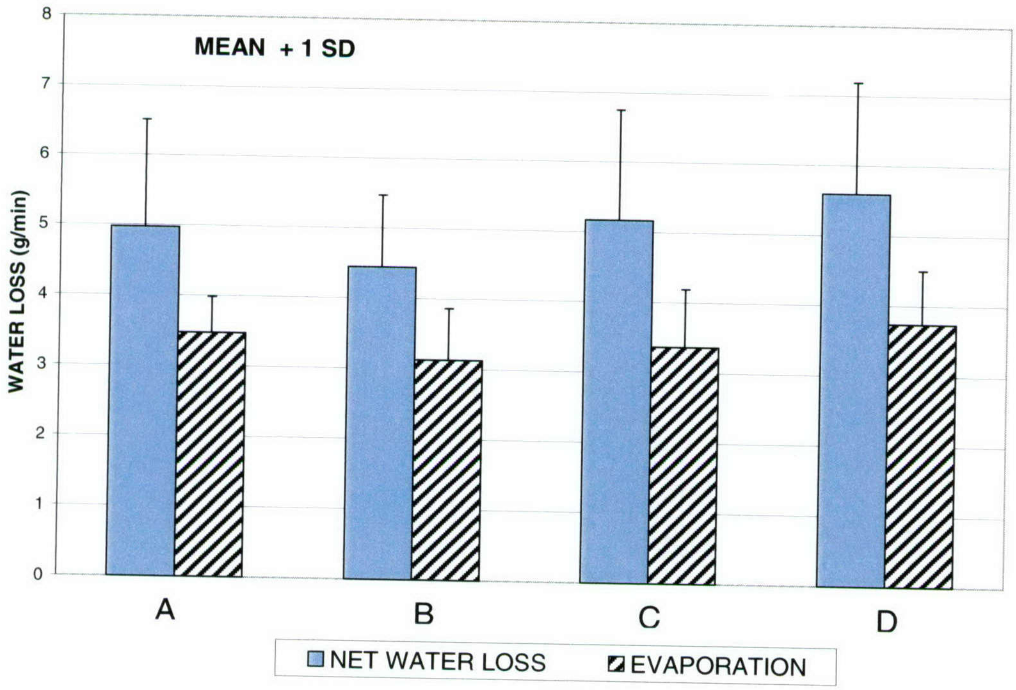
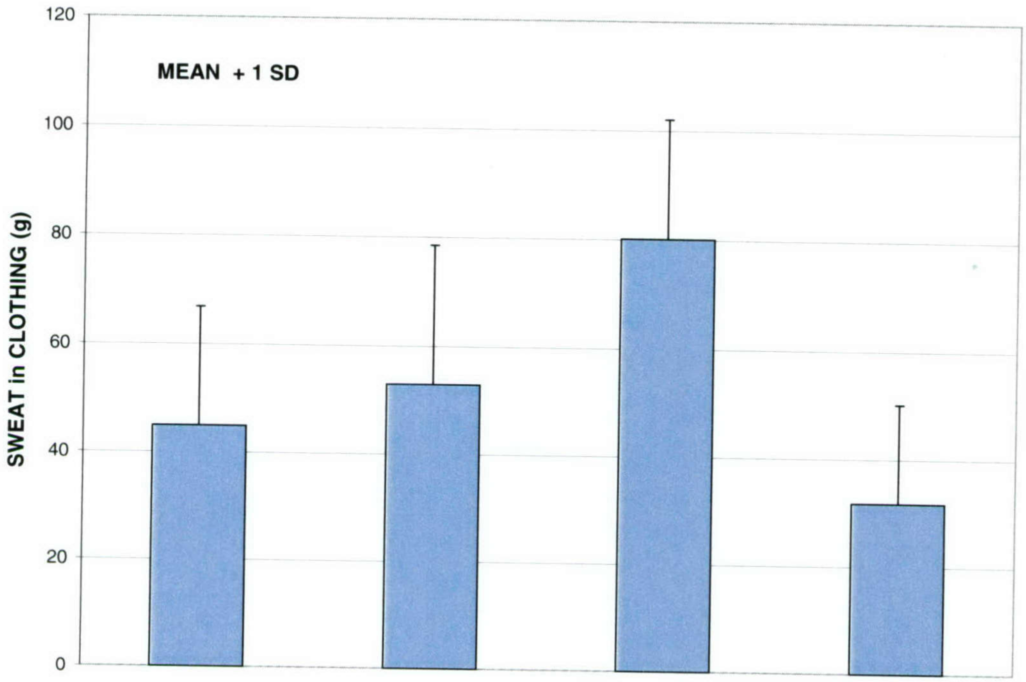


Figure 10. Sweat retained in clothing (SW_{cl}) under warm-humid (27°C, 75% RH) conditions.



Statistical Analysis – Physiological Data: Statistical analysis was performed using a General Linear Model (GLM). When overall differences were significant ($\alpha \leq 0.05$), Tukey's Studentized Range Test was used to determine which pairs were significantly different ($\alpha = 0.05$). The two environments were evaluated independently. Variables were T_{re}, ΔT_{re}, T_{sk}, ΔT_{sk}, T_b, RH, ω, (Table 3) rate of water loss (R_w), rate of evaporative loss (R_{ev}), percentage of sweating efficiency (%Eff), and sweat retention in clothing (SW_{cl}) (Table 4).

For the NC condition, the effect of cycle (sequential change, cycle=rest+walk) for most variables was significant, but when there was an interaction of cycle and garment type, no overall conditions were found to be significant. In general results for the WH condition were similar, but overall differences were found for the interaction of cycle and garment for the change in $\overline{RH}_{uc}$, and T_{sk}. The interaction for T_{sk} was obtained only when data were heavily edited, whereas all other results were obtained with and without heavy data editing. The "cycle" analysis sequentially compared the mean value for each 40 min cycle. A significant interaction was also found between time and garment for T_b. The "time" analysis compared variable values for all four garments at the same point in time at 10 min intervals for the entire test session. For those variables where the overall differences were significant ($\alpha \leq 0.05$), Tukey's Studentized Range Test was used to determine which pairs were significantly different ($\alpha = 0.05$). For Sw_{cl}, there were significant differences between C and the other garments (C>A,B and D). For R_{ev}, only the difference between the B-D pair was significant (D>B).

Table 3. Mean, standard deviation (SD) and total input values (n) for rectal temperature (T_{re}), change in rectal temperature from baseline (ΔT_{re}), mean skin temperature ($\overline{T}_{sk}$), body temperature $\overline{T}_b$ (T_b), mean percent skin surface relative humidity ($\overline{RH}$) and mean skin wettedness (ϖ).

	Thermal Neutral (NC/CTRL) 20°C, 50% RH				Warm Humid (WH) 27°C, 75% RH			
	T_{re} (°C)				T_{re} (°C)			
CLOTHING	A	B	C	D	A	B	C	D
MEAN	37.26	37.23	37.31	37.25	37.30	37.33	37.26	37.30
SD	0.26	0.24	0.23	0.33	0.27	0.24	0.34	0.25
n	1535	1532	1537	1534	1535	1524	1520	1518
	ΔT_{re} (°C)				ΔT_{re} (°C)			
MEAN	0.23	0.23	0.22	0.31	0.37	0.33	0.32	0.34
SD	0.20	0.15	0.18	0.19	0.25	0.20	0.21	0.24
n	1535	1532	1537	1534	1535	1524	1520	1414
	T_{sk} (°C)				T_{sk} (°C)			
MEAN	31.23	32.00	31.64	32.06	33.27	33.02	33.11	33.10
SD	0.82	0.84	1.17	0.61	0.64	0.65	0.80	0.86
n	1535	1530	1537	1534	1535	1524	1518	1356
	T_b (°C)				T_b (°C)			
MEAN	36.66	36.71	36.74	36.73	36.90	36.90	36.85	36.86
SD	0.24	0.23	0.20	0.30	0.24	0.20	0.28	0.22
n	1535	1532	1537	1534	1535	1524	1518	1347
	RH (%)				RH (%)			
MEAN	43.35	40.28	40.29	40.35	75.24	80.24	78.91	79.74
SD	10.66	7.18	6.79	6.55	13.37	10.96	10.50	10.29
n	1535	1411	1537	1534	1367	1514	1518	1278
	ω (n.d.)				ω (n.d.)			
MEAN	0.18	0.14	0.15	0.14	0.43	0.43	0.44	0.43
SD	0.13	0.08	0.10	0.07	0.18	0.17	0.18	0.17
n	1364	1335	1365	1533	1192	1354	1480	892

Table 4. Mean, standard deviation (SD) and total input values (n) for percentage of sweating efficiency (%Eff), and sweat retention in clothing (SW_{cl}), rate of water loss (R_w), and rate of evaporative loss (R_{ev})

Thermal Neutral (TN/CTRL) 20°C, 50% RH				Warm Humid (WH) 27°C, 75% RH			
A	B	C	D	A	B	C	D
%Eff				%Eff			
63.79	59.86	63.31	62.17	74.47	71.83	68.06	70.82
27.74	20.74	23.81	25.42	19.18	12.14	16.83	19.55
9	8	8	9	9	8	9	8
SW_{cl} (g)				SW_{cl} (g)			
14.17	60.45	54.97	8.06	44.83	52.89	80.09	31.74
15.97	130.53	95.17	5.45	22.03	25.65	21.98	18.42
8	9	8	9	9	9	9	9
R_w (g/min)				R_w (g/min)			
3.71	3.65	3.73	4.38	4.97	4.44	5.16	5.38
1.45	1.62	1.59	2.40	1.53	1.03	1.57	1.63
9	9	9	9	9	8	9	9
R_{ev} (g/min)				R_{ev} (g/min)			
2.02	2.11	2.04	2.19	3.47	3.13	3.37	3.77
0.36	0.80	0.65	0.33	0.51	0.73	0.82	0.72
9	9	8	9	9	9	9	9

CLOTHING FRICTION TEST RESULTS

The skin-clothing friction test consisted of slowly pulling a strip of fabric across the forearm of the Soldier subject (Figure 11). The coefficient of friction (f) results of these tests are displayed in Figure 12. It is seen that f has low steady values for measurements made at the NC conditions but increases markedly for the WH conditions. The skin wettedness results measured on the arm during the friction test are plotted in Figure 13. The pattern is similar to the friction results, i.e. skin wettedness was low and relatively steady for NC conditions but increased substantially during the test at WH conditions, thus implying f is dependent on skin moisture. The dependence is clarified in Figure 14 where f is plotted against skin wettedness.

FIGURE 11. Skin – friction test measurement.

FIGURE 12. Skin/fabric coefficient of friction (f) results (mean of 9 subjects) for warm-humid (27°C, 75% RH) environment.

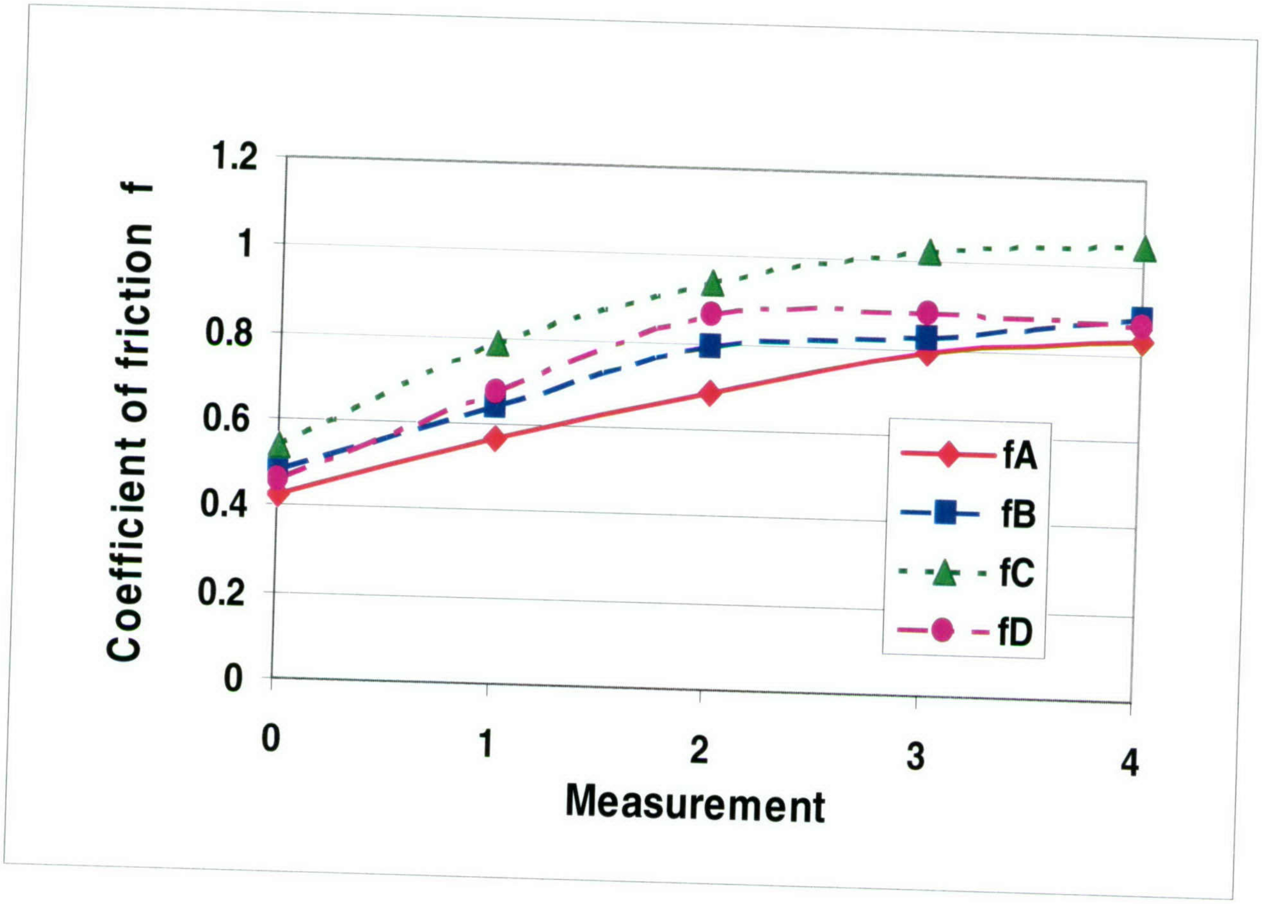


FIGURE 13. Skin wettedness (mean of 9 subjects) of arm during rest periods of friction test in neutral (n = 20°C, 50% RH) and warm-humid (w = 27°C, 75% RH) environment.

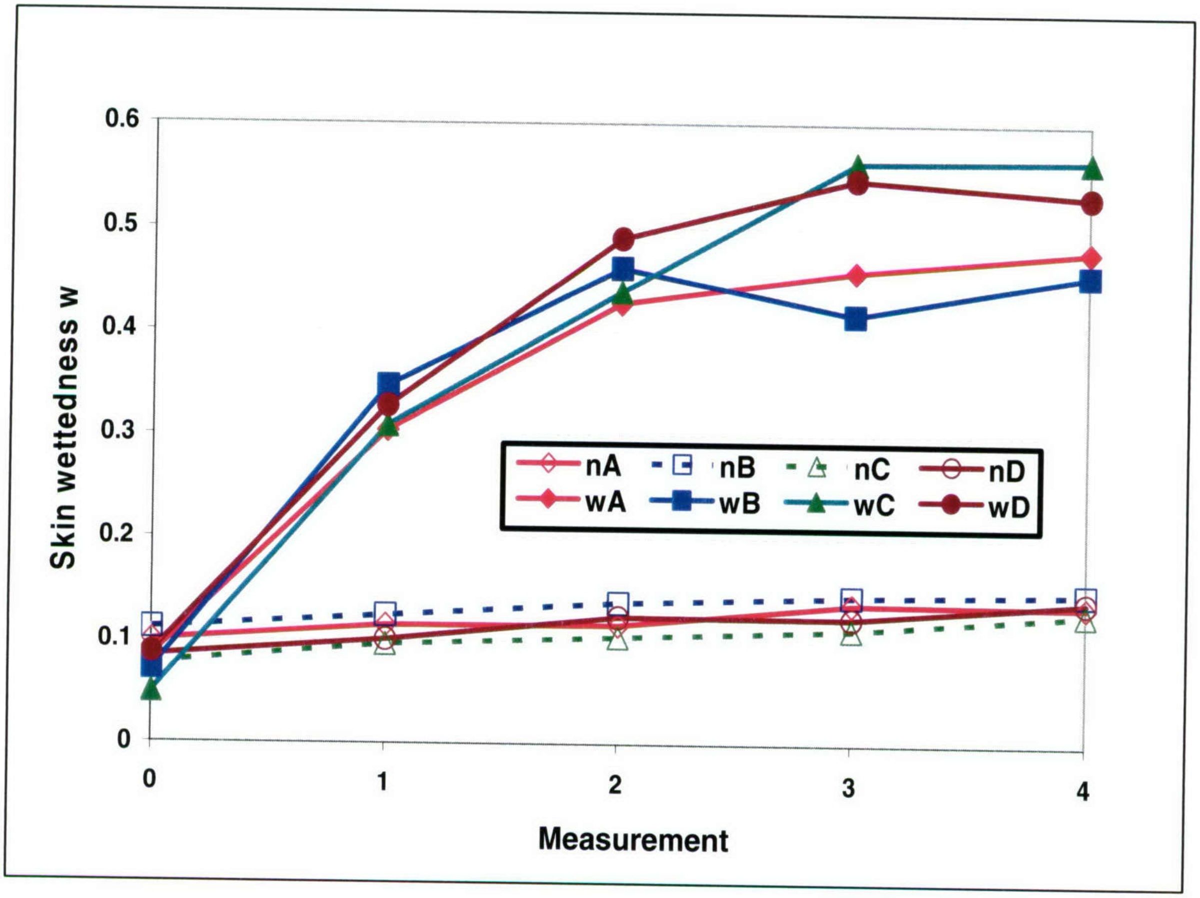
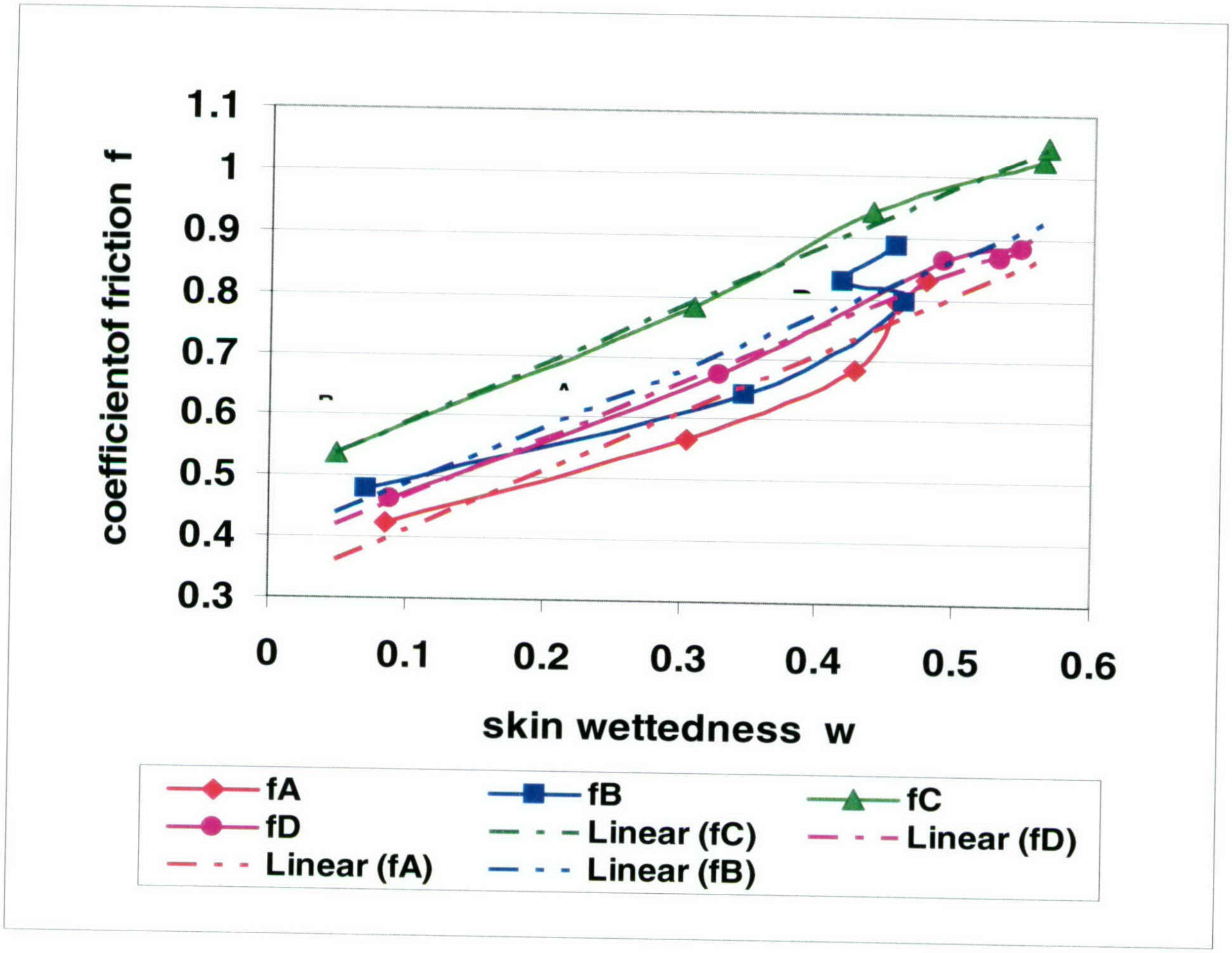


Figure 14. Relationship between coefficient of friction (f) and skin wettedness (w) for warm-humid (27°C, 75% RH) environment.



The skin friction test did not discriminate between uniforms in the NC (20°C) environment where ϖ did not exceed 0.15 (15%) for any uniform. At such moisture levels the outer stratum corneum of the skin apparently remained hard and had little effect on sliding friction. However in the WH (27°C) environment, skin moisture became higher and had a strong effect on sliding friction. The linearity between f and ω for the tests at the warm humid conditions is quantified for each fabric in Table 5 which presents predictive equations for the skin friction coefficient (f) for the 4 uniforms. R^2 ranged from 0.877 to 0.995.

TABLE 5. Predictive equation for skin friction coefficient (f) based on skin wettedness (ω) in the warm-humid environment (27°C, 75% RH)

uniform	Intercept (β_0)	Slope (β_1)	R^2
Australian (A)	0.3137	0.9853	0.924
Light-weight BDU (B)	0.3936	0.9479	0.877
Canadian (C)	0.4885	0.9831	0.995
Nomex© (D)	0.3746	0.9452	0.993
* $f = \beta_0 + \beta_1 \bullet \omega$			

SENSORY AND COMFORT RELATED RESULTS

Means and standard deviations for all questionnaire items appear in Appendices E (pre- and post-test questionnaire), F (seated questionnaire) and G (walking questionnaire). Repeated measures ANOVAs were conducted to examine the main effects of environmental condition (NC vs. WH), time, and garment fabric type, as well as all possible interaction effects for the items on the seated and walking questionnaires. F-values, sums of squares, mean squares, degrees of freedom, and exact probabilities for all items from these questionnaires appear in Appendices H (seated) and I (walking).

As a control to ensure that all garments, regardless of the fabric from which they were constructed, fit the participants equally well, the pre-test questionnaire asked a series of questions about the perceived fit of the garments both as an ensemble, as well as for individual garment/body areas. These latter questions focused on the perceived length of various body/garment parts (trunk, sleeves, legs, crotch) and the perceived looseness/tightness in various body/garment areas (trunk, collar, waist, seat). The ratings for these perceived fit criteria can be found in Appendix E. Ratings for all perceived fit criteria fall within approximately 0.5 scale units of the "just right" category (1 = too short/loose; 3= just right, 5= too long/tight). The one exception was for the garment constructed from the Canadian fabric, for which the trunk and collar were rated slightly more than 0.5 units from "just right", i.e. 2.44. However, within-subjects ANOVAs conducted on the overall evaluation of the perceived fit of the garments at the start of the study and again at the end of the study found no significant differences in perceived fit by garment fabric, nor any difference in fit among participants assigned to the control versus WH environmental condition. In addition, a comparison of the judgments of overall perceived fit before the start of each day's testing (pre-test questionnaire) and after completion of that day's testing (post-test questionnaire) showed no significant changes in perceived fit.

Of some special importance to the interpretation of the data from this study is the fact that the pre-test ratings of both the "liking of the feel" of the garment and "comfort" showed significant differences by garment type (Liking of the Feel: $F = 31.7$, df = 3,24, $p < .001$; Comfort: $F = 20.0$, df = 3,24, $p < .001$). Examination of the mean data (Appendix E) shows that both the liking for feel and comfort of the garment fabricated with the Canadian material were rated significantly lower than all the other garments and that the Canadian garment was the only one that received negative ratings on these perceptual

and affective dimensions. The garment fabricated from the Australian material rated slightly more positively than the Hot Weather BDU garment, and both were rated better (greater) than the Nomex garment on these attributes.

Table 6 shows the F-values and the levels of significance for all items on the walking questionnaire. As can be seen in Table 6, there were significant main effects of environmental condition on all questionnaire items. Examination of the data in Appendix I shows that in the WH condition, participants rated their effort expended, thermal sensation, skin wettedness and clothing/skin contact sensation significantly higher than in the control condition. In addition, for each of these subjective judgments, there was a significant effect of time, whereby the intensity of these perceptions increased over time. Comfort was rated as significantly lower in the WH condition, although there was no effect over time. Garment fabric type had a significant effect on both comfort and clothing/skin contact sensation, with the Canadian fabric being perceived as less comfortable than the other three fabrics, especially in the WH condition and the skin/contact sensation was also higher for the Canadian fabric, especially in the NC condition.

Table 7 shows the F-values and the levels of significance for all items on the seated questionnaire. While all effects observed on the walking questionnaire were also found on the seated questionnaire, the items of the seated questionnaire showed some additional main and interaction effects. This greater sensitivity for matching items on the seated questionnaire versus the walking questionnaire may be due to a reduction in attention during the walking questionnaire, due to the need to maintain walking balance while on the treadmill, or to greater response variability, due to the use of linear graphic rating scales in which placement of a response mark on the lines may have been affected by the motion of the participants' hand during walking. For this reason, only the data for items on the seated questionnaire are plotted for presentation here.

Table 6. ANOVA F-Values for the Main and Interaction Effects for all Rated Items on the Walking Questionnaire.

	Effort Expended	Comfort	Hot/Cold Body Feel	Wet/Dry Skin Feel	Clothing/Skin Contact Sensation
Env. Condition	24.483**	21.917**	63.633**	82.258**	34.813**
Garment	2.530^{m}	7.886**	1.413	1.895	5.309**
Time	4.179*	1.619	8.142**	12.314**	10.913**
Env. Condition x Garment	2.058	0.531	0.620	2.756^{m}	0.433
Env. Condition x Time	2.348^{m}	1.295	2.372^{m}	0.403	6.816**
Garment x Time	0.976	0.848	0.754	0.234	1.465
Env. Condition x Garment x Time	0.691	1.228	1.581	1.290	0.784

Significance Levels of F-Values for Main and Interaction Effects for all Rated Items on the Walking Questionnaire.
** significance less than 0.01 * significance less than 0.05 m significance. between 0.05 and 0.10

Table 7a. ANOVA F-Values for the Main and Interaction Effects for all Rated Items on the Seated Questionnaire. – part a.

	Stiff	Sticky	Clammy	Clingy	Scratchy	Soft	Air Quality (Fresh-Stale)	Air Quality (Pleasant-Unpleasant)
Env. Condition	3.894^{m}	46.965**	36.301**	56.756**	8.579*	0.396	15.096*	16.405**
Garment	2.597^{m}	4.938**	1.497	4.855**	27.983**	6.321**	0.813	0.219
Time	1.229	30.890**	19.735**	18.383**	7.348**	0.237	2.812*	0.434
Env. Condition x Garment	1.827	2.971^{m}	2.686^{m}	2.826^{m}	4.023**	0.174	0.111	0.526
Env. Condition x Time	8.651**	12.457**	12.579**	12.832**	2.862*	1.093	1.722	1.022
Garment x Time	1.683^{m}	1.372	0.964	1.725^{m}	1.823	2.084*	2.429*	1.294
Env. Condition x Garment x Time	1.134	0.794	0.979	0.998	3.403**	0.795^{m}	0.452	1.531

Significance Levels of F-Values for Main and Interaction Effects for all Rated Items on the Walking Questionnaire.
** significance less than 0.01 * significance less than 0.05 m significance. between 0.05 and 0.10

Table 7b. ANOVA F-Values for the Main and Interaction Effects for all Rated Items on the Seated Questionnaire - continued.

	Air Temp	Preferred Temp	Humidity	Comfort	Hot/Cold Body Feel	Sweaty	Wet Skin	Wet/Dry Skin Feel
Env. Condition	311.481**	53.046**	13.360**	22.510**	59.155**	167.307*	183.235**	53.828**
Garment	0.532	1.683	1.317	8.835**	1.972	4.987*	3.636*	3.576*
Time	9.217**	2.270^{m}	0.185	7.006**	46.966**	39.871*	29.638**	24.745**
Env. Condition x Garment	2.152	2.074	0.453	1.645	0.230	5.983*	3.457*	0.169
Env. Condition x Time	0.396	2.979*	1.227	3.343*	1.455	52.607*	28.354**	13.476**
Garment x Time	1.000	1.872*	0.671	0.568	0.552	1.710^{m}	1.212	1.214
Env. Condition x Garment x Time	1.074	0.637	0.889	1.535	1.344	1.057	0.565	2.153*

Significance Levels of F-Values for Main and Interaction Effects for all Rated Items on the Walking Questionnaire.
** significance less than 0.01 * significance less than 0.05 m significance. between 0.05 and 0.10

Figure 15 shows comfort ratings made using the CALM scale while participants were seated. Data are plotted over time for each of the garments and environmental conditions. ANOVA showed significant effects of environmental condition (NC vs. WH), garment type, and time (Table 7). In addition, there was a temperature x time interaction. Examination of Figure 15 shows that comfort was significantly lower in the WH condition (27C, 75% RH) than in the control condition (20C, 50% RH) and that there was a gradual decrease in comfort as time elapsed in the study; whereas, in the control condition comfort levels showed no significant decrement over time. In both test conditions, comfort was significantly lower for the garment fabricated form the Canadian material (C) than all other garments, with only relatively differences in comfort among the other fabrics tested.

Post-test ratings of comfort showed significant effects of both the environmental condition ($F = 12.3$, $df = 1$, $p < .01$) and garment type ($F = 22.7$, $df = 3$, $p < .001$), with no interaction. Comfort was significantly lower in the WH condition, regardless of garment type, and the garment produced from the Canadian fabric reached lower comfort levels (-36, -9) after the 4 h than either the Nomex garment (-8, +35), the hot weather BDU garment (+4, +26) or the garment produced with the Australian fabric (-2, +47). ANOVA also showed the comfort ratings to decline significantly from pre-test to post-test, but only in the WH condition ($F = 18.2$, $df = 1$, $p < .005$).

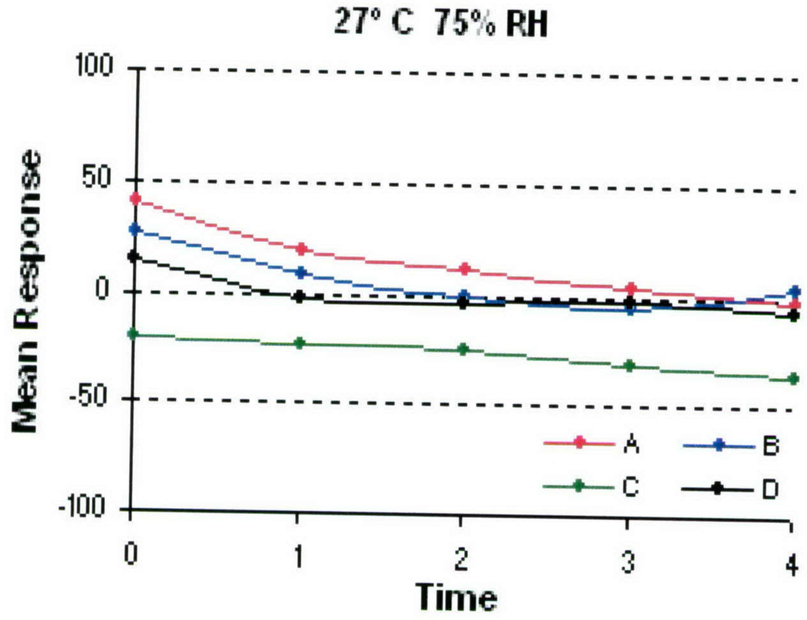
Figure 16 shows the data for thermal sensations (hot/cold). The data in Table 7 show significant effects of both time and environmental condition, but no effect of garment fabric and no interaction effects. Participants rated their thermal sensation as significantly hotter in the WH test condition, while in both conditions, thermal sensations increased and then reached asymptote as time progressed in the study.

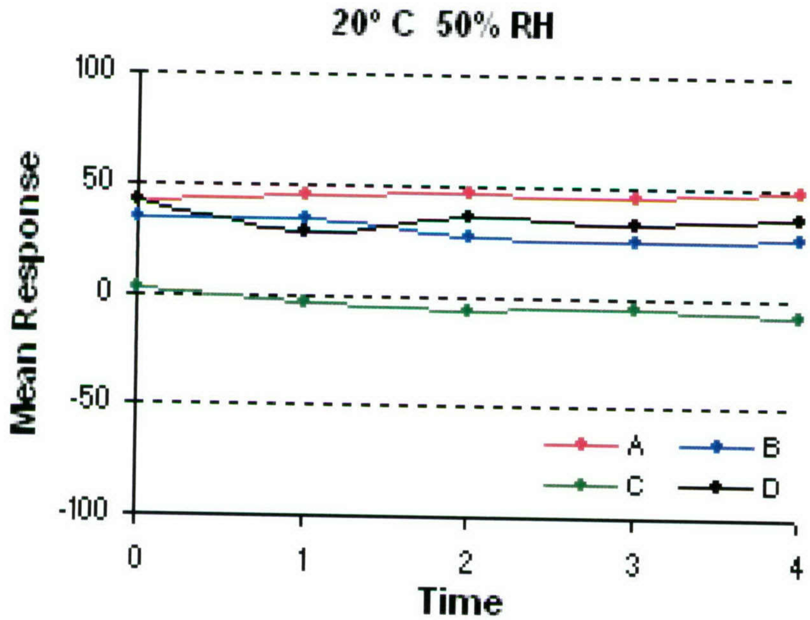
Perceptions of the air temperature in the test chamber during the study (data not shown) were inversely parallel (due to scale directionality) to the data for thermal sensation (Figure 16), showing a significant effect of environmental condition and time (Table 7). In addition, there was no significant effect of fabric type nor any interaction effects. In keeping with the ratings of thermal perception, air temperature was perceived to be higher (warmer) in the WH condition than in the control condition and decreased to a steady state level after 1-2 hours.

Figure 17 shows the data for preferred air temperature. As with the thermal perception data and the ratings of perceived air temperature, there was a significant effect of environmental condition (Table 7) that showed a preference for cooler air temperature in the WH test condition. However, the effect of time was only marginal.

Figure 18 shows the data for sweatiness. Here there were statistically significant effects of time, environmental condition, and fabric type, with significant condition x fabric and condition x time effects (Table 7). Examination of the data in Figure 18 shows a dramatic increase in perceptions of sweat over time in the WH condition, but only a minor increase in the NC condition. In the WH condition, greatest sweatiness resulted during wear of the Canadian fabric (C), followed in order by the Nomex fabric (D), hot weather BDU fabric (B), and the Australian fabric (A).

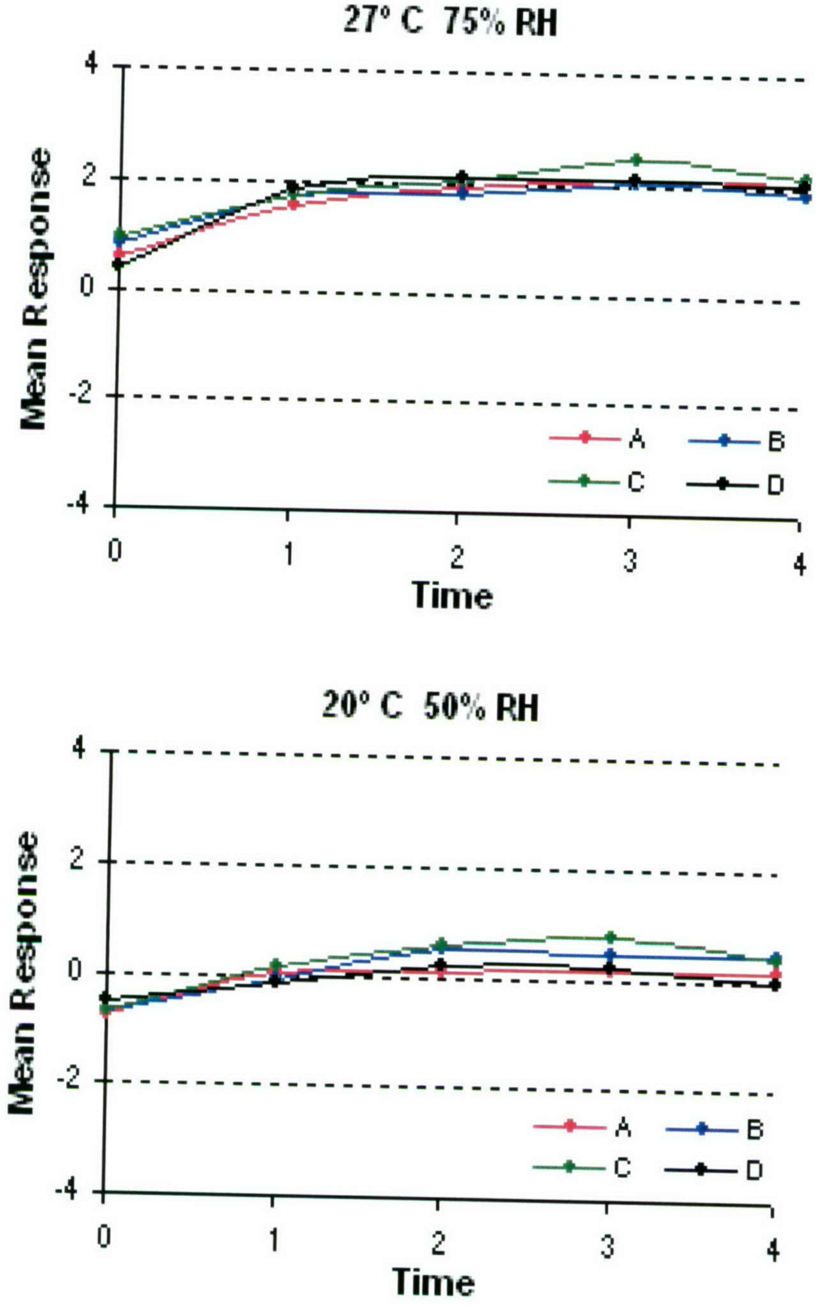
Figure 15. Ratings of comfort plotted over time (h) for each of the four garments, by environmental condition.





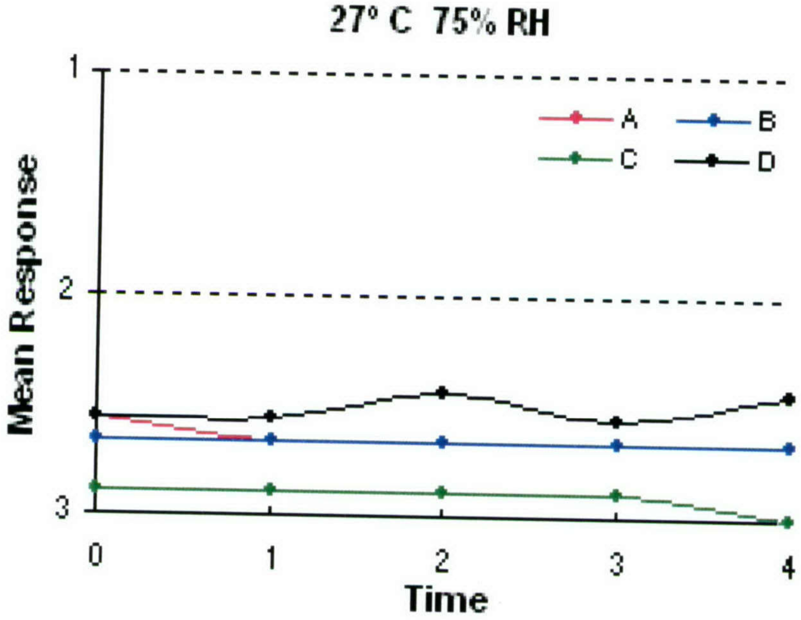
Comfort
(-100 = Greatest Imaginable Discomfort, 100 = Greatest Imaginable Comfort)

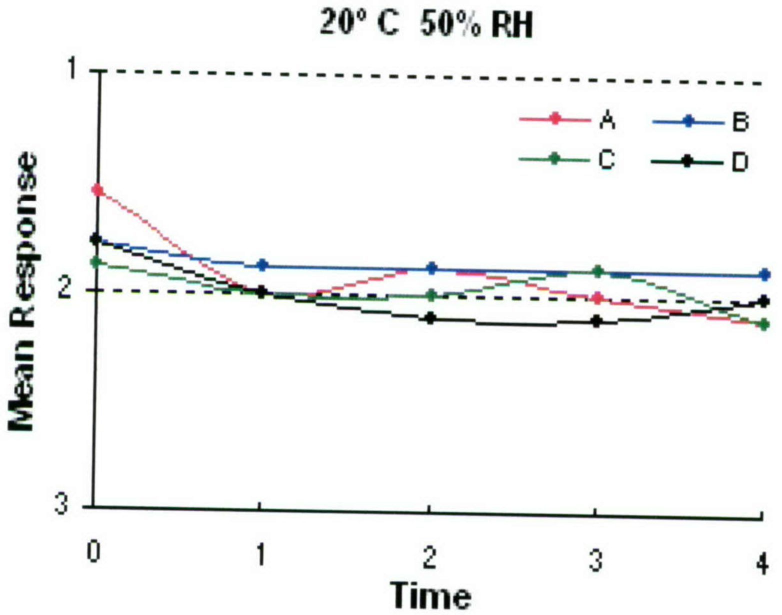
Figure 16. Ratings of thermal sensations (hot / cold) plotted over time (h) for each of the four garments, by environmental condition.



How hot or cold does your body feel?
(-4 = Very COLD, 4 = Very HOT)

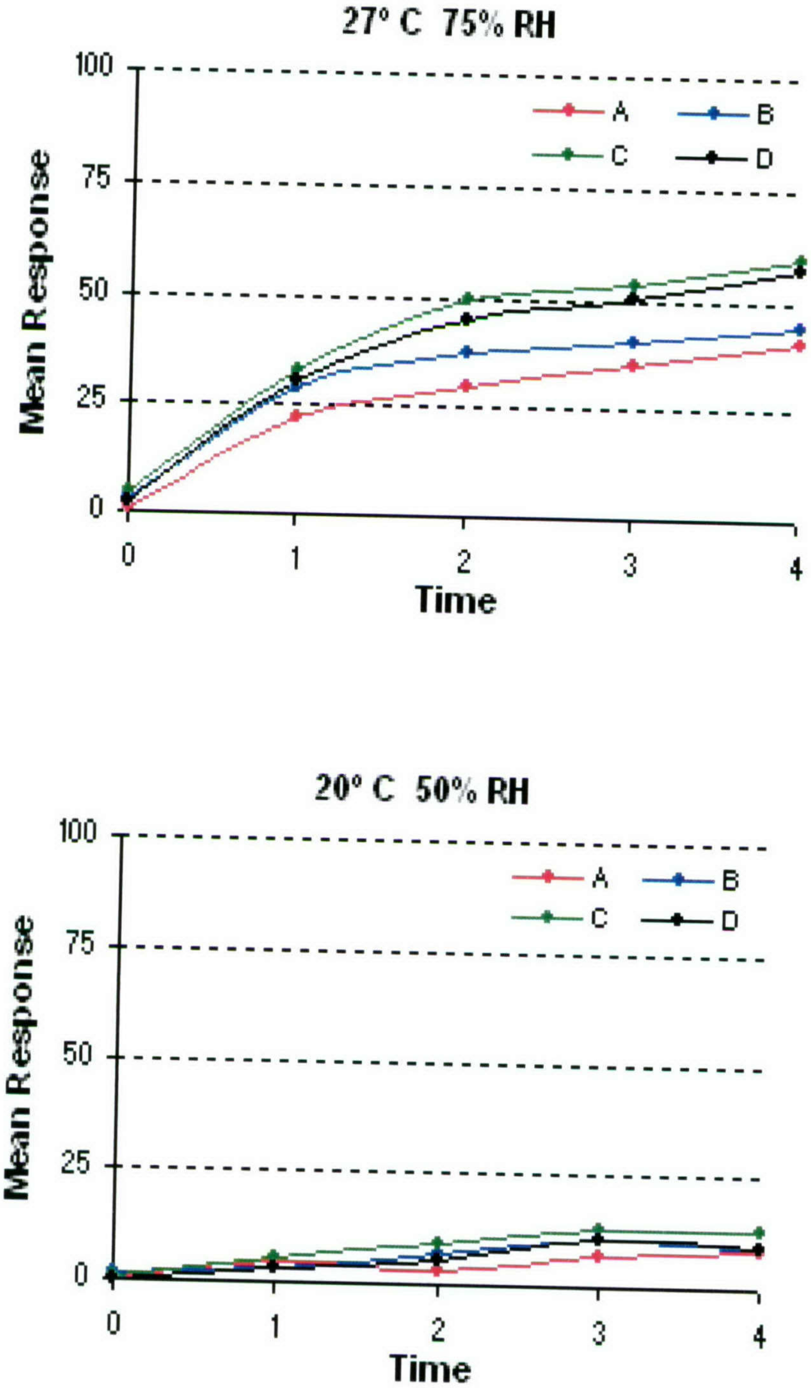
Figure 17. Mean ratings of preferred air temperature plotted over time (h) for each of the four garments, by environmental condition.





Preferred Temperature
(1 = WARMER, 2 = NO CHANGE, 3 = COLDER)

Figure 18. Mean ratings of sweatiness plotted over time for each of the four garments, by environmental condition.



SWEATY SENSATION
(0 = Not at all, 100 = Extremely Strong)

Figure 19 shows the data for sensations of "wet skin". The data parallel closely the data for the perception of sweat in Figure 18. Again, there were significant effects of time, environmental condition and fabric type, with significant effects between condition x fabric and condition x time (Table 7).

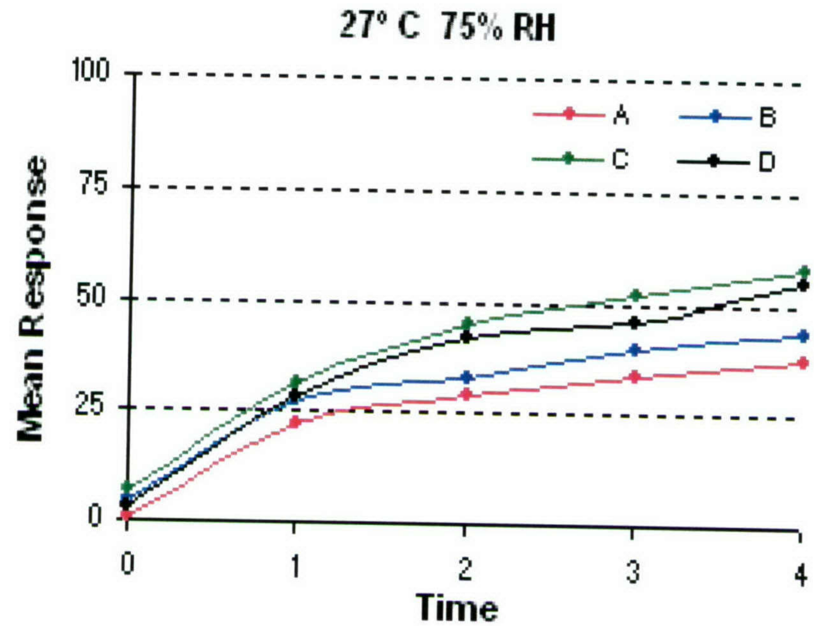
Figure 20 shows the data for perceptions of stickiness. These data generally parallel those for sweatiness and skin-wettedness, showing significant main effects of time, environmental condition, and test fabric. In addition there was a significant interaction of time with environmental condition. In the WH condition perceptions of stickiness increased dramatically over time for all test fabrics. A slower rate of increase with time is seen in the control condition. As with the data for sweatiness and skin-wettedness, the Canadian fabric (C) produced greater perceptions of stickiness, although this was primarily in the control condition.

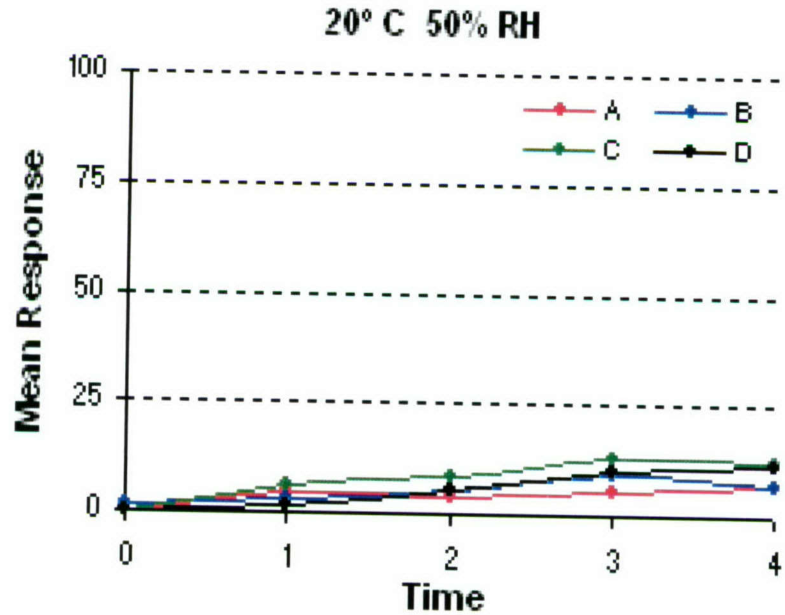
Figure 21 shows the data for the skin feel sensation of scratchiness. Time, environmental condition and fabric type were all significant, along with significant condition x time, condition x fabric and condition x fabric x time interaction effects Table 7). For both environmental conditions and across all time periods, the Canadian fabric (C) was significantly more scratchy than all the other fabric types. The other three fabrics were more similar to one another, with the Nomex fabric (D) being scratchier than the hot weather BDU fabric (B), which was marginally more scratchy than the Australian fabric (A).

Figure 22 shows the data for perceptions of softness. Only fabric type showed a significant effect, although there was a significant fabric x time interaction (Table 7). The softest feeling fabric was the Australian fabric (A), followed by the hot weather BDU fabric (B), especially during the first two hours of the study. The Nomex fabric (D) and the Canadian fabric (C) had the lowest levels of softness perception.

An analysis of the ratings of the liking of the feel of the garments obtained at the completion of the test revealed significant effects of environmental condition ($F = 33.8$, $df = 1$, $p < .001$) and garment type ($F = 23.1$, $df = 3$, $p < .001$), but no interaction effect. For all garments, liking of the feel of the garment was significantly lower in the WH condition. In addition, the only garment for which the "feel" ratings were negative was the garment constructed from the Canadian fabric (-60, -32). Liking of the feel of the garment increased, in order, for the Nomex garment (+8, +31), Hot Weather BDU garment (+38, +54) and the garment constructed from the Australian material (+52, +66). ANOVA also showed the "feel" ratings to decline significantly from pre-test levels in the WH condition ($F = 18.5$, $df = 1$, $p < .005$).

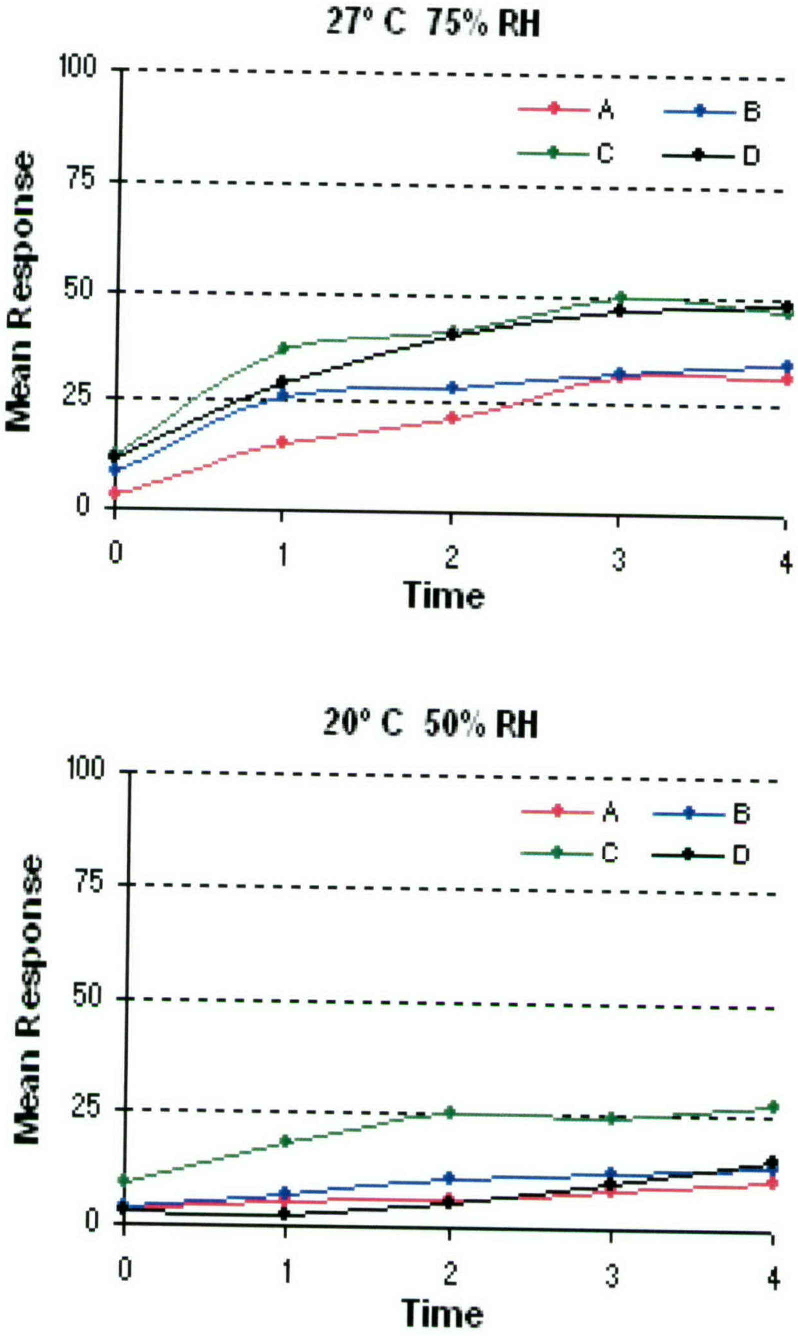
Figure 19. Ratings of "wet skin" sensation plotted over time (h) for each of the four garments, by environmental condition.





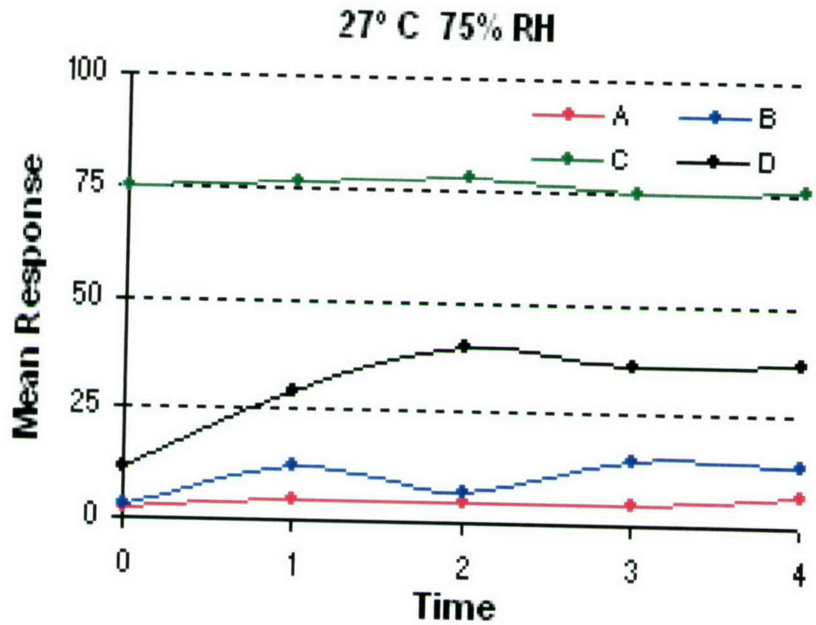
WET SKIN SENSATION
(0 = Not at all, 100 = Extremely Strong)

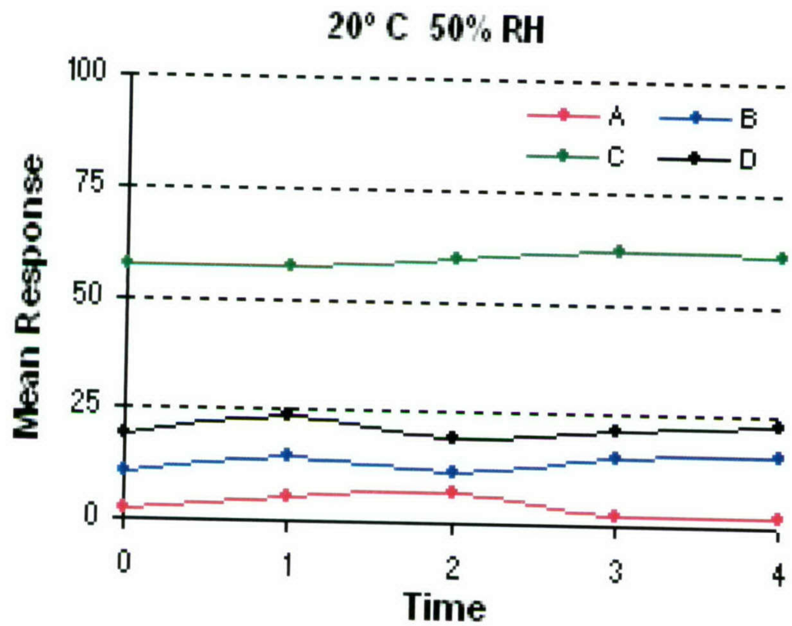
Figure 20. Ratings of “stickiness” sensation plotted over time (h) for each of the four garments, by environmental condition.



STICKY SENSATION
(0 = Not at all, 100 = Extremely Strong)

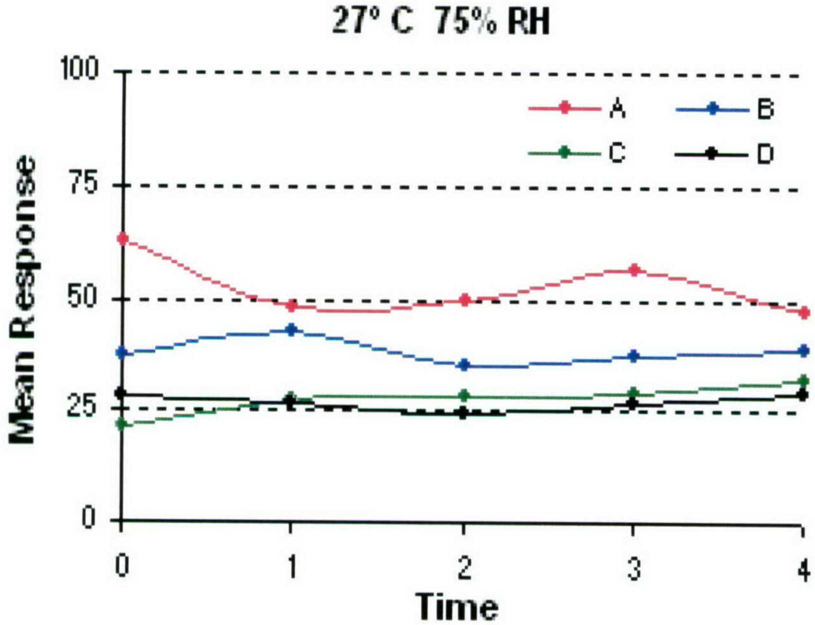
Figure 21. Ratings of garment "scratchiness" plotted over time (h) for each of the four garments, by environmental condition.

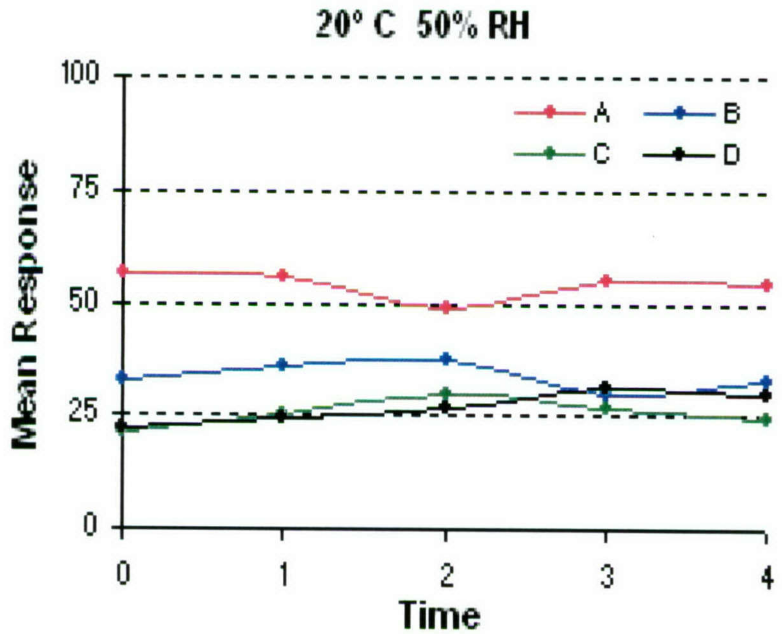




SCRATCHY SENSATION
(0 = Not at all, 100 = Extremely Strong)

Figure 22. Ratings of perceived "softness" over time (h) for each of the four garments, by environmental condition.





SOFT SENSATION
(0 = Not at all, 100 = Extremely Strong)

DISCUSSSION

The four garments cannot be considered in terms of physical properties to be completely equivalent (Table 2), but in terms of differences that resulted in physiological significant differences in response, the differences were primarily due to factors related to moisture. One can speculate that while sweat retained in clothing (SW_{cl}) may elevate skin moisture and impact comfort perception, only evaporative loss (R_{ev}) is thermo-physiologically meaningful as only sweat that is evaporated alters heat exchange with the environment. There were no significant differences between garments observed for variables related to the subjects' overall or net thermal state (T_{re} or T_b).

The fact that judgments of the perceived fit of the garments generally fell in the "just right" category and that judgments of overall fit did not differ significantly by garment fabric type, by environmental condition, or from pre- to post-testing provides strong evidence that any effects of the garments or environmental conditions on comfort or skin contact sensations were not due to differences in the fit of the garments. In addition, the Canadian fabric, which rated somewhat further from the "just right" category on tightness/looseness of the trunk and collar than the other garment fabrics, actually was rated as "looser" in these areas, making it unlikely that this minor difference in fit could have contributed to greater discomfort during wear.

The pre-test ratings of the "feel" and "comfort" of the test garment showed large and significant effects. In all cases the garment constructed from the Canadian fabric had significantly lower ratings than the other garments on these attributes. In addition, the garments constructed from the Australian material and the Hot Weather BDU materials rated highest on these pre-test attributes, with the garment produced with the Nomex material falling between these garments and the Canadian garment. These pre-test data show that the garments differed significantly in comfort and tactile feel *prior to the start of the test* and independent of any environmental or metabolic loads. Thus, differences among the garments observed subsequently on these subjective dimensions during the walking and seated conditions of the test may be partly (or entirely) due to the differences in the tactile characteristics of the fabrics from which the garments were fabricated.

Although the physiological effects during the walking and seated portions of the test were mostly related to moisture properties, the different garment fabrics did have significant effects on thermal perception and comfort, as well as on moisture-related perceptions of the participants. In general, the Canadian garment fabric resulted in significantly greater perceptions of moisture (sweat and skin-wettedness) and heat, and in significantly lower ratings of comfort, especially in the WH condition. This finding is consistent with the literature that relates discomfort to increasing skin moisture.

With regard to skin contact attributes, the Canadian (C) garment was also perceived to be the most abrasive (scratchy) fabric during the test, whereas, the Australian (A) garment fabric was perceived as the softest. To a lesser extent the stiffer Nomex (D) was also perceived to be less comfortable. These differences in the skin feel sensations of the garments, combined with the observed pre-test differences among the garments for "feel" and "comfort" suggest that the tactile characteristics of the fabrics

contributed, along with the moisture and thermal sensations, to the overall assessment of the comfort of the garments during the study. The overall findings for the relative comfort of the garments were consistent with the anticipated response that cotton fabrics tend to be more comfortable, while wool blends and stiffer materials are more likely to produce discomfort.

The skin fabric friction results are very interesting and discriminating. The Australian cotton polyester blend fabric consistently exhibited the least resistance to sliding across the skin with and without sweating. With sweating in the warm (WH) environment, the Canadian wool polyester blend consistently had the highest resistance to sliding of the 4 fabrics tested. Similarly the skin moisture or measured skin wettedness levels were consistently the driest under the Australian cotton polyester fabric of the 4 fabrics with (WH) and without (NC) sweating. And in the WH environment, the wettest skin was measured under the Canadian 65%wool and 35% polyester blend fabric.

The relationship between the friction and skin resistance was very linear, and accounts for approximately 95% of the variance off. Considering the very simple nature of the measurements involved, this is a strong correlation. The results support the theory that with increasing moisture, the skin's stratum corneum becomes increasingly soft, so the fabric fibers can increasingly deform the normally dry, hard skin. The deformation and increased contact area between fiber and skin contribute to the fabrics resistance to sliding.

To place the results in perspective to actual conditions, people rarely indicate that they are thermal comfortable when their skin wettedness is above 20% (Berglund,1998). In these tests skin wettedness was less than 20% for the NC conditions and greater that 20% in the WH environment for all measurements once the treadmill walking started.

CONCLUSIONS

There are statistically significant differences between some of the tested uniforms in terms of insulation (I_T), water vapor permeability (i_m) and cooling power ($i_m \cdot clo^{-1}$). There were significant differences between garments A and C (C>A), D and all three other garments (D>A,B,C) for I_T; and for i_m and $i_m \cdot clo^{-1}$ between D and B or C (B,C>D) However, the actual value of these differences are small, and do not generally appear to have any significant physiological effects.

The use of body weight and water loss data was not particularly effective in discriminating between the different test uniforms. In WH environment, for water retention Sw_{cl}, there were significant differences between the wool garment (C) and all three other garments (C > A, B, D). For R_{ev}, only the difference between the B-D pair (D>C) was significant.

In terms of relating the physical properties of clothing to the physiological responses, the difference between B and D for R_{ev} (D>B) could be related to the significant differences in I_T, i_m and $i_m \cdot clo^{-1}$ for the same pair of garments. The difference in I_T means was the greatest between these two garments (D=1.34 vs. C=1.30), and B is more permeable to water vapor (i_m), thus results in small increase in potential for cooling ($i_m \cdot clo^{-1}$). Other significant differences between garments in the physical properties are not reflected by any difference in R_{ev}. For Sw_{cl} there is little relationship between statistically significant differences in the physical properties of the garments (C>A for I_T, C>D for i_m, $i_m \cdot clo^{-1}$) and physiological significant differences between garments.

The skin friction test was an effective means of discriminating between the uniforms under WH conditions. The primary limitation of the method is the requisite test conditions – uniform activity and environment sufficient to induce moderate to high level of sweating. The skin friction test did not discriminate between uniforms in the NC (20°C) environment where ϖ was low.

The subjective measures showed large overall differences between test environments. The ability to discriminate between materials was better in the WH environment, especially in terms of responses related to moisture. The effect of time on perception was only marginal in the control (NC) condition. In terms of skin contact, the wool blend Canadian fabric (C) was significantly worse than the other garments, and the somewhat stiff Nomex (D) also had poor skin contact sensations.

The study was designed to accomplish two goals. The first goal was to specifically compare the four test garments in terms of subject physiological responses, the skin friction test and the subjective questionnaires. The study results, primarily the skin friction test and the subject questionnaire, did provide significant findings which generally were most favorable to the cotton blend Australian (A) fabric and least favorable for the wool blend Canadian (C) fabric. The second goal was to evaluate the test design as a format for future comfort studies. The test scenario for the WH 27°C environment allowed discrimination between uniforms of varying subjective comfort and physical properties. In contrast, the results for the NC 20°C environment, except for scratchiness and

softness, were not significant. Thus, the number of test days could be reduced by eliminating the neutral condition, or a different hot-dry environment could be substituted to provide information for a second, relatively extreme condition. The study indicates that the simple scratchiness rating test done at room temperature could be a good indicator of some important clothing comfort perceptions and could be useful in preliminary assessment of fabrics.

Both the skin friction test and the subjective questionnaires provided relatively simple, easy to administer test methods that allowed discrimination between materials that were identical in design and similar in thermal properties. The study demonstrated the efficacy of questionnaires for quantifying comfort parameters under laboratory conditions. It is likely that these two methods could be used under less controlled conditions, such as an outdoor test or exercise, with a degree of confidence that the tests would provide valid information regarding the relative performance of the different clothing materials.

REFERENCES

1. ASHRAE. Fundamentals. American Society of Heating and Air-conditioning Engineers, Inc., Atlanta, GA, 1993.

2. Berglund, L.G. Comfort and Humidity. *ASHRAE J.* 40(8): 35-41, 1998.

3. Berglund, L. , and D. Cunningham. Parameters of human thermal discomfort in warm environments. ASHRAE Transactions, Vol.92(2):732-746, 1986.

4. Borg, G. A category scale with ratio properties for intermodal and interindividual comparisons. In: Geissler, H.G. and Pextold, P. (Eds), Psychophysical Judgment and the Process of Perception. VEB Deutscher Verlag der Wissenschaften, Berlin, pp. 25-34, 1982.

5. Cardello, A.V., R. Bell, D. Marshall, C. Winterhalter, H.L. Meiselman, and H.G. Schutz, H.G. A multifaceted approach to sensory and marketing research on clothing. Abstract of paper to be presented at the 3rd Rosemary Pangborn Sensory Science Symposium, Alesund, Norway, 9-13 June 1998.

6. Cardello, A.V., C. Winterhalter, and H.G. Schutz. Predicting the handle and comfort of military clothing fabrics from sensory and instrumental data: development and application of new psychological methods. *Textile Research Journal,* 73(3):221-237, 2003.

7. Eissing G. Climatic assessment indices. *Ergonomics,* 38(1):47-57, 1995.

8. Fanger, P.O. Thermal Comfort, New York: McGraw-Hill, 1972.

9. Fuzek, J.F. Some factors affecting the comfort assessment of knit t-shirts. *Industrial and Engineering Chemical Product Research and Development* 20: 254-259, 1981.

10. Gagge, A.P., J.A.J. Stolwijk, and J.D. Hardy. Comfort and thermal sensations and associated physiological responses at various ambient temperatures. *Environmental Research,* 1: 1-20, 1967.

11. Gagge, A.P., J.A.J. Stolwijk, and B. Saltin. Comfort and thermal sensations and associated physiological responses during exercise at various ambient temperatures. *Environmental Research,* 2: 209-229, 1969.

12. Gagge, A.P. and Y. Nishi. Physical indices of the thermal environment. *ASHRAE Journal,* 18(1):47-51, 1976.

13. Gonzalez, R.R. Magnitude estimates of thermal discomfort. *ASHRAE Transactions,* 79: 88-96, 1973.

14. Gonzalez, R.R. and Y. Nishi Effects of cool environments on local thermal sensation, discomfort and clothing selection. *ASHRAE Transactions,* 82: 76-86, 1977.

15. Green, B.G., G.S. Shaffer, and M.M. Gilmore. Derivation and evaluation of a semantic scale of oral sensation magnitude with apparent ratio properties. *Chemical Senses,* 18: 683-702, 1993.

16. Gwosdow, A.R., J.C. Stevens, L.G. Berglund, and J.A.J. Stolwijk. Skin Friction and Fabric Sensations in Neutral and Warm Environments. *Textile Research Journal,* 56: 574-580, 1986.

17. Hollies, N.R.S. (1965). Investigation of the factors influencing comfort in cotton apparel fabrics. Contract 12-14-100-7183(72), US Dept. of Agriculture, New Orleans. [Referenced in Hollies et al., 1979.]

18. Hollies, N.R.S., A.G. Custer, C.J. Morin, and M.E. Howard. A human perception analysis approach to clothing comfort. *Textile Research Journal,* 49: 557-564, 1979.

19. Markee, N.L., K.L. Hatch, H.I. Maibach, R.L. Barker, P. Radhakrishnaiah, and S.S. Woo. In vivo cutaneous and perceived comfort response to fabric. Part IV: Perceived sensation to three experimental garments worm by subjects exercising in a hot, humid environment. *Textile Research Journal,* 60: 561-568, 1990.

20. Marks, L.E. and R.R. Gonzalez. Skin temperature modifies the pleasantness of thermal stimuli. *Nature,* 247: 473-475, 1974.

21. Mehrtens, D.G. and K.C. McAlister. Fiber properties responsible for comfort. *Textile Research Journal,* 32: 658-665, 1962.

22. Morris, M.A., H.H. Prato, and N.L. White. Relationship of fiber content and fabric properties to comfort of socks. *Clothing and Textile Research Journal,* 3: 14-19, 1984-85.

23. Ramanathan, N.L. A new weighting system for mean surface temperature of the human body. *Journal of Applied Physiology,* 19(3):531-533, 1964.

24. Santee, W.R. and L.A. Blanchard. Thermal properties of handwear at varying altitudes. *Aviation, Space and Environmental Medicine,* 72: 576-578, 2001.

25. Schutz, H.G. and A.V. Cardello. Development of a labeled magnitude scale for assessing food liking/disliking. *Journal of Sensory Studies,* 16: 117-159, 2001.

26. Sweeney, M.M. and D.H. Branson. Sensorial comfort. Part I: A psychophysical method for assessing moisture sensation in clothing. *Textile Research Journal,* 60: 371-377, 1990a.

27. Sweeney, M.M. and D.H. Branson. Sensorial comfort. Part II: A magnitude estimation approach for assessing moisture sensation. *Textile Research Journal,* 60: 477-452, 1990b.

28. Vogel, J.A., J.W. Kirkpatrick, P.I. Fitzgerald, J.A. Hodgdon, and E.A. Harmon. *Derivation of anthropmetry based body fat equations for the Army's weight control program.* Natick, MA: U.S. Army Research Institute of Environmental Medicine, Technical Report T17-88, 1988.

29. Vokac, A., V. Kopke, and P. Keul. Effect of cooling of peripheral parts of the body on general thermal comfort. *Textile Research Journal,* 41: 827-833, 1971.

30. Yaglou, C.P. and M.N. Rao. Loose versus close-fitting clothing for work in "tropical heat". *Journal of Industrial Hygiene and Toxicology*, 29: 140-142, 1947.

Appendix A
Pre-test Questionnaire

Pre-Test Questionnaire – BDU Chamber Comfort Study

Volunteer # ____________ Test Day ____________

Garment # ____________

Please answer the following questions about the BDU that you are wearing today. There are no right or wrong answers. We are interested only in your opinions about the BDU, so please answer as honestly as possible. (Circle one number for each question/scale below)

1. Please rate how **long/short** each of the following parts of your BDU are:

	Too short		Just Right		Too Long
Shirt Trunk	1	2	3	4	5
	Too short		Just Right		Too Long
Shirt Sleeves	1	2	3	4	5
	Too short		Just Right		Too Long
Pant Legs	1	2	3	4	5
	Too short		Just Right		Too Long
Pant Crotch	1	2	3	4	5

2. Please rate how **loose/tight** each of the following parts of your BDU are:

	Too loose		Just Right		Too tight
Shirt Trunk	1	2	3	4	5
	Too loose		Just Right		Too tight
Shirt Collar	1	2	3	4	5
	Too loose		Just Right		Too tight
Pant Waist	1	2	3	4	5
	Too loose		Just Right		Too tight
Pants Seat	1	2	3	4	5

3. Overall, how well does this BDU **fit** you? (circle one)

Fits very poorly 1 2 3 4 5 6 7 Fits very well

4. How much do you like or dislike the **feel** of this BDU? (Place a slash somewhere on the line below)

100 GREATEST IMAGINABLE LIKE
80
LIKE EXTREMELY
60
LIKE VERY MUCH
40
LIKE MODERATELY
20
LIKE SLIGHTLY
0 NEITHER LIKE NOR DISLIKE
DISLIKE SLIGHTLY
-20
DISLIKE MODERATELY
-40
DISLIKE VERY MUCH
-60
DISLIKE EXTREMELY
-80
-100 GREATEST IMAGINABLE DISLIKE

5. Overall, how **comfortable/uncomfortable** is this BDU? (Place a slash somewhere on the line below)

100 GREATEST IMAGINABLE COMFORT
80
EXTREMELY COMFORTABLE
60
VERY COMFORTABLE
40
MODERATELY COMFORTABLE
20
SLIGHTLY COMFORTABLE
0 NEITHER COMFORTABLE NOR UNCOMFORTABLE
-20 SLIGHTLY UNCOMFORTABLE
-40
MODERATELY UNCOMFORTABLE
-60 VERY UNCOMFORTABLE
-80
EXTREMELY UNCOMFORTABLE
-100 GREATEST IMAGINABLE DISCOMFORT

Physiological And Psychological Assessment Of Volunteers Wearing Air Permeable Battle-Dress (BDU) Uniforms During Intermittent Exercise (H02-02) Dr Santee (PI)

Within Test Questionnaire: Seated – BDU Chamber Comfort Study

Volunteer # ____________
Garment # ____________

Test Day ____________
Time ____________

1. Using the adjectives and scales below, please rate how the **fabric** of this BDU feels against your skin **right now**. (Please place a slash through the lines below to indicate the strength of each sensation)

Stiff:

- **MAXIMAL**

100 — EXTREMELY STRONG
90 —
80 —
70 — VERY STRONG
60 —
50 — STRONG
40 — SOMEWHAT STRONG
30 — MODERATE
20 — WEAK
10 — VERY WEAK
5 — EXTREMELY WEAK (JUST NOTICEABLE)
0 — NOT AT ALL

Sticky:

- **MAXIMAL**

100 — EXTREMELY STRONG
90 —
80 —
70 — VERY STRONG
60 —
50 — STRONG
40 — SOMEWHAT STRONG
30 — MODERATE
20 — WEAK
10 — VERY WEAK
5 — EXTREMELY WEAK (JUST NOTICEABLE)
0 — NOT AT ALL

Clammy:

- **MAXIMAL**

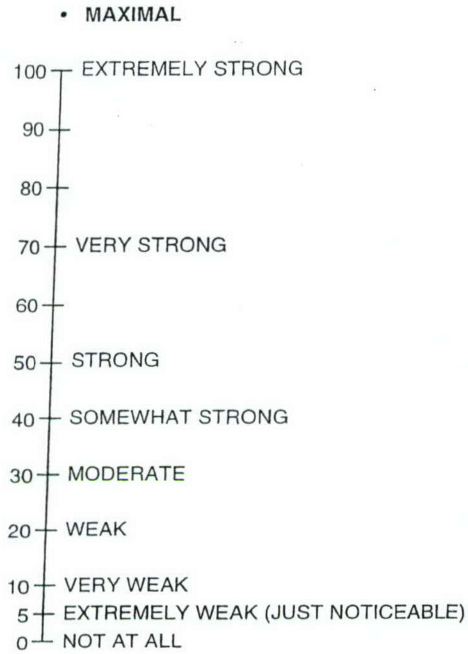
100 — EXTREMELY STRONG
90 —
80 —
70 — VERY STRONG
60 —
50 — STRONG
40 — SOMEWHAT STRONG
30 — MODERATE
20 — WEAK
10 — VERY WEAK
5 — EXTREMELY WEAK (JUST NOTICEABLE)
0 — NOT AT ALL

Clingy:

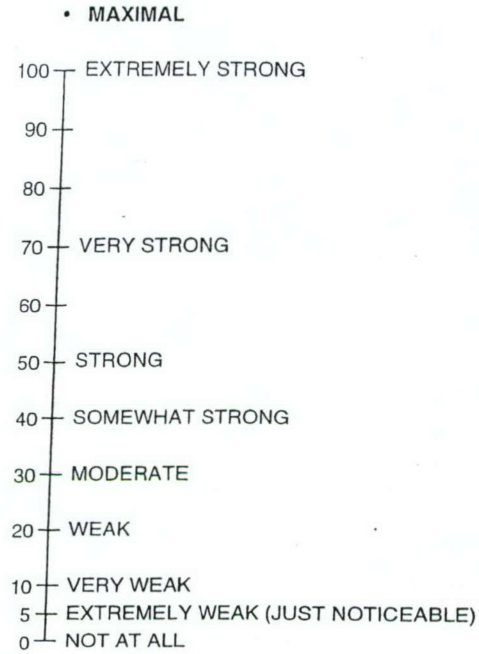
- **MAXIMAL**

100 — EXTREMELY STRONG
90 —
80 —
70 — VERY STRONG
60 —
50 — STRONG
40 — SOMEWHAT STRONG
30 — MODERATE
20 — WEAK
10 — VERY WEAK
5 — EXTREMELY WEAK (JUST NOTICEABLE)
0 — NOT AT ALL

Scratchy:



Soft:



2. Please rate the quality of the air in the chamber **right now** in terms of its **freshness or staleness**: (circle one number)

    1. Very fresh
    2. Moderately fresh
    3. Slightly fresh
    4. Neither fresh nor stale
    5. Slightly stale
    6. Moderately stale
    7. Very stale

3. Please rate the quality of the air in the chamber today in terms of its **pleasantness/unpleasantness**: (circle one number)

    1. Very pleasant
    2. Moderately pleasant
    3. Slightly pleasant
    4. Neither pleasant nor unpleasant
    5. Slightly unpleasant
    6. Moderately unpleasant
    7. Very unpleasant

4. Please rate the **temperature** of the air in the chamber **right now**:
(circle one number)

1. Very hot
2. Hot
3. Warm
4. Neither warm nor cool
5. Cool
6. Cold
7. Very cold

5. How would you **prefer the temperature** in the chamber to be **right now**?
(circle one number)

1. Warmer
2. No change
3. Cooler

6. Please rate the **humidity** of the air in the chamber today:
(circle one number)

1. Very humid
2. Moderately humid
3. Slightly humid
4. Neither humid nor dry
5. Slightly dry
6. Moderately dry
7. Very dry

7. How **comfortable/uncomfortable** do you feel **right now?** (Place a slash through the line below to indicate your degree of comfort or discomfort)

100	GREATEST IMAGINABLE COMFORT
80	
	EXTREMELY COMFORTABLE
60	VERY COMFORTABLE
40	MODERATELY COMFORTABLE
20	
	SLIGHTLY COMFORTABLE
0	NEITHER COMFORTABLE NOR UNCOMFORTABLE
-20	SLIGHTLY UNCOMFORTABLE
-40	MODERATELY UNCOMFORTABLE
-60	VERY UNCOMFORTABLE
-80	EXTREMELY UNCOMFORTABLE
-100	GREATEST IMAGINABLE DISCOMFORT

8. How **hot or cold** does your whole body feel **right now**? (Place a slash on the line)

VERY HOT	+4
HOT	+3
WARM	+2
SLIGHTLY WARM	+1
NEUTRAL	0
SLIGHTLY COOL	-1
COOL	-2
COLD	-3
VERY COLD	-4

9. How **sweaty** are you **right now**?
(Please place a slash through the line below to indicate the strength of this sensation)

- • **MAXIMAL**
- 100 — EXTREMELY STRONG
- 90 —
- 80 —
- 70 — VERY STRONG
- 60 —
- 50 — STRONG
- 40 — SOMEWHAT STRONG
- 30 — MODERATE
- 20 — WEAK
- 10 — VERY WEAK
- 5 — EXTREMELY WEAK (JUST NOTICEABLE)
- 0 — NOT AT ALL

10. How **wet** does your skin feel **right now**?
(Please place a slash through the line below to indicate the strength of this sensation)

- • **MAXIMAL**
- 100 — EXTREMELY STRONG
- 90 —
- 80 —
- 70 — VERY STRONG
- 60 —
- 50 — STRONG
- 40 — SOMEWHAT STRONG
- 30 — MODERATE
- 20 — WEAK
- 10 — VERY WEAK
- 5 — EXTREMELY WEAK (JUST NOTICEABLE)
- 0 — NOT AT ALL

11. How **wet or dry** does your skin feel **right now**? (Place a slash on the line)

- SOAKING/DRIPPING WET — 6
- 5
- 4
- NEUTRAL/NORMAL — 3
- 2
- 1
- VERY DRY — 0

12. Where does the **clothing/skin unpleasantness** feel greatest? (Check one)

neck ______
chest ______
back ______
arms ______
crotch ______
legs ______
ankles ______
feet ______

Appendix C
Chamber walking questionnaire

Within Test Questionnaire: Walking – BDU Chamber Comfort Study

Volunteer # ____________ Test Day ____________

Garment # ____________ Time ____________

1. Rate the **amount of effort** that you expended toward the end of the last walking period. (Please place a slash through the line below to indicate the level of this effort)

• MAXIMAL

100 EXTREMELY STRONG
90
80
70 VERY STRONG
60
50 STRONG
40 SOMEWHAT STRONG
30 MODERATE
20 WEAK
10 VERY WEAK
5 EXTREMELY WEAK (JUST NOTICEABLE)
0 NOT AT ALL

2. How **comfortable/uncomfortable** do you feel **right now**? (Place a slash on the line)

100 GREATEST IMAGINABLE COMFORT
80
EXTREMELY COMFORTABLE
60
VERY COMFORTABLE
40
MODERATELY COMFORTABLE
20
SLIGHTLY COMFORTABLE
0 NEITHER COMFORTABLE NOR UNCOMFORTABLE
SLIGHTLY UNCOMFORTABLE
-20
-40
MODERATELY UNCOMFORTABLE
-60 VERY UNCOMFORTABLE
-80
EXTREMELY UNCOMFORTABLE
-100 GREATEST IMAGINABLE DISCOMFORT

3. How **hot or cold** does your whole body feel **right now?** (slash line)

VERY HOT +4
HOT +3
WARM +2
SLIGHTLY WARM +1
NEUTRAL 0
SLIGHTLY COOL -1
COOL -2
COLD -3
VERY COLD -4

4. How **wet or dry** does your skin feel **right now?** (slash line)

SOAKING/DRIPPING WET 6
5
4
NEUTRAL/NORMAL 3
2
1
VERY DRY 0

5. How does the **clothing/skin contact** sensation feel **right now**? (slash line)

VERY STICKY 6
5
4
3
2
1
NONE/VERY SLIPPERY 0

Appendix D
Post-test questionnaire

Physiological And Psychological Assessment Of Volunteers Wearing Air Permeable Battle-Dress (BDU) Uniforms During Intermittent Exercise (H02-02) Dr Santee (PI)

Post-Questionnaire – BDU Chamber Comfort Study

Volunteer # __________ Test Day __________

Garment # __________

Please answer the following questions about the BDU you wore today. There are no right or wrong answers. We are interested only in your opinion about the BDU, so please answer as honestly as possible.
(Circle one number for each question/scale below)

1. Overall, how well did this BDU **fit** you? (Circle one)

Fit very poorly 1 2 3 4 5 6 7 Fit very well

2. How much did you like or dislike the **feel** of this BDU? (Place a slash somewhere on the line below)

100 GREATEST IMAGINABLE LIKE
80
LIKE EXTREMELY
60
LIKE VERY MUCH
40
LIKE MODERATELY
20
LIKE SLIGHTLY
0 NEITHER LIKE NOR DISLIKE
DISLIKE SLIGHTLY
-20
DISLIKE MODERATELY
-40
DISLIKE VERY MUCH
-60
DISLIKE EXTREMELY
-80
-100 GREATEST IMAGINABLE DISLIKE

3. How **comfortable/uncomfortable** was this BDU? (Place a slash somewhere on the line below)

100 GREATEST IMAGINABLE COMFORT
80
EXTREMELY COMFORTABLE
60
VERY COMFORTABLE
40
MODERATELY COMFORTABLE
20
SLIGHTLY COMFORTABLE
0 NEITHER COMFORTABLE NOR UNCOMFORTABLE
-20 SLIGHTLY UNCOMFORTABLE
-40
MODERATELY UNCOMFORTABLE
-60 VERY UNCOMFORTABLE
-80
EXTREMELY UNCOMFORTABLE
-100 GREATEST IMAGINABLE DISCOMFORT

Additional comments about the BDU: ____________________

____

____

____

Appendix E
Results – Dressing Room Pre- and Post-test Questionnaires

Pre-Questionnaire: Question 1
How LONG/SHORT are the parts of the BDU? (1=Too Short, 3=Just Right, 5=Too Long)

	Garment	Trunk	Sleeves	Legs	Crotch	
Australian	A	3.11	3.00	3.06	2.89	Mean
		90	90	90	90	N
		0.32	0.00	0.23	0.32	St. Dev.
US Army Hot Weather BDU	B	3.06	3.06	3.00	2.89	
		90	90	90	90	
		0.23	0.23	0.00	0.32	
Canadian	C	3.28	3.56	3.06	3.00	
		90	90	90	90	
		0.45	0.69	0.23	0.34	
US Army Aviator BDU (Nomex)	D	3.33	3.33	3.06	2.89	
		90	90	90	90	
		0.47	0.58	0.23	0.32	
	Overall	3.19	3.24	3.04	2.92	
		360	360	360	360	
		0.40	0.51	0.20	0.32	

Pre-Questionnaire: Question 2
How LOOSE/TIGHT are the parts of the BDU? (1=Too Loose, 3=Just Right, 5=Too Tight)

	Garment	Trunk	Collar	Waist	Seat	
Australian	A	2.72	2.67	3.06	3.11	Mean
		90	90	90	90	N
		0.45	0.58	0.23	0.32	St. Dev.
US Army Hot Weather BDU	B	2.78	2.83	2.94	3.06	
		90	90	90	90	
		0.42	0.37	0.23	0.23	
Canadian	C	2.44	2.44	2.89	2.94	
		90	90	90	90	
		0.60	0.60	0.32	0.41	
US Army Aviator BDU (Nomex)	D	2.61	2.72	2.83	2.89	
		90	90	90	90	
		0.68	0.45	0.50	0.32	
	Overall	2.64	2.67	2.93	3.00	
		360	360	360	360	
		0.56	0.53	0.35	0.33	

Pre-Questionnaire: Question 3 / Post-Questionnaire: Question 1
Overall, how well does/did this BDU fit you? (1=Very poorly, 7=Very well)

	Garment	PRE 27° C 75% RH	PRE 20° C 50% RH	PRE Overall	POST 27° C 75% RH	POST 20° C 50% RH	POST Overall	
Australian	A	6.11	5.88	6.00	5.89	6.00	5.94	Mean
		45	40	85	45	45	90	N
		0.88	1.28	1.09	1.21	1.26	1.23	St. Dev.
US Army Hot Weather BDU	B	6.00	6.13	6.06	5.89	6.22	6.06	
		45	40	85	45	45	90	
		1.07	1.28	1.17	1.30	1.24	1.28	
Canadian	C	4.88	5.22	5.06	5.44	5.22	5.33	
		40	45	85	45	45	90	
		1.56	1.57	1.56	1.27	1.41	1.34	
US Army Aviator BDU (Nomex)	D	5.25	5.56	5.41	5.11	5.44	5.28	
		40	45	85	45	45	90	
		1.50	1.08	1.29	1.30	1.52	1.41	
	Overall	5.59	5.68	5.63	5.58	5.72	5.65	
		170	170	340	180	180	360	
		1.36	1.35	1.35	1.30	1.41	1.36	

Note Subject V (make-up) missed this question on Day 1 of testing. Garment A

Note Subject III (make-up) missed this question on Day 2 of testing. Garment B

Note Subject II (make-up) missed this question on Day 2 of testing. Garment C

Note Subject III (make-up) missed this question on Day 5 of testing. Garment D

Pre-Questionnaire: Question 4 / Post-Questionnaire: Question 2
How much do you Like or Dislike the FEEL of this BDU?
(-100=Greatest Imaginable Dislike. 100=Greatest Imaginable Like)

	Garment	PRE 27° C 75% RH	PRE 20° C 50% RH	PRE Overall	POST 27° C 75% RH	POST 20° C 50% RH	POST Overall	
Australian	A	54.37	58.81	56.59	51.70	65.93	58.81	Mean
		45	45	90	45	45	90	N
		24.34	31.35	27.99	28.13	17.14	24.24	St. Dev.
US Army Hot Weather BDU	B	48.15	50.22	49.19	38.96	54.37	46.67	
		45	45	90	45	45	90	
		17.53	22.88	20.29	23.87	44.59	36.40	
Canadian	C	-52.00	-43.41	-47.70	-60.00	-31.56	-45.78	
		45	45	90	45	45	90	
		44.59	34.01	39.67	39.92	48.59	46.47	
US Army Aviator BDU (Nomex)	D	23.85	24.44	24.15	8.15	30.96	19.56	
		45	45	90	45	45	90	
		31.86	26.79	29.27	40.82	34.08	39.11	
	Overall	18.59	22.52	20.56	9.70	29.93	19.81	
		180	180	360	180	180	360	
		52.54	49.48	51.00	54.92	53.42	55.04	

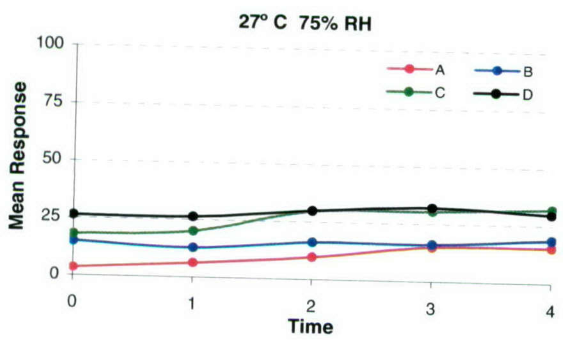
Pre-Questionnaire: Question 5 / Post-Questionnaire: Question 3
How COMFORTABLE or UNCOMFORTABLE is this BDU?
(-100=Greatest Imaginable Discomfort. 100=Greatest Imaginable Comfort)

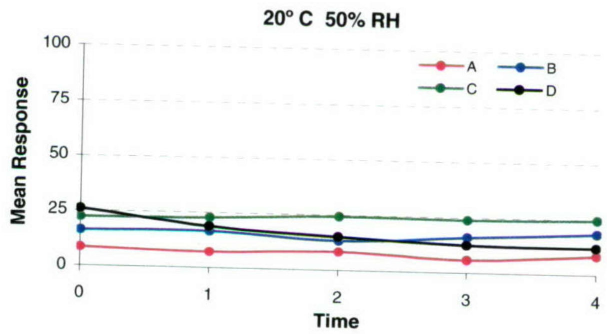
	Garment	PRE 27° C 75% RH	PRE 20° C 50% RH	PRE Overall	POST 27° C 75% RH	POST 20° C 50% RH	POST Overall	
Australian	A	58.81	62.37	60.59	48.15	65.33	56.74	Mean
		45	45	90	45	45	90	N
		25.21	25.25	25.15	35.71	18.94	29.71	St. Dev.
US Army Hot Weather BDU	B	54.07	53.48	53.78	34.22	52.89	43.56	
		45	45	90	45	45	90	
		13.32	15.21	14.22	35.05	20.30	29.98	
Canadian	C	-38.67	-30.37	-34.52	-48.74	-37.48	-43.11	
		45	45	90	45	45	90	
		47.85	41.14	44.57	49.84	39.72	45.16	
US Army Aviator BDU (Nomex)	D	38.96	25.63	32.30	3.11	29.48	16.30	
		45	45	90	45	45	90	
		24.00	43.40	35.51	39.68	33.52	38.85	
	Overall	28.30	27.78	28.04	9.19	27.56	18.37	
		180	180	360	180	180	360	
		49.61	49.10	49.29	54.82	49.37	52.90	

Appendix F
Results - Seated Questionnaire

Seated Questionnaire: Question 1a
STIFF SENSATION (0 = Not at all, 100 = Extremely Strong)

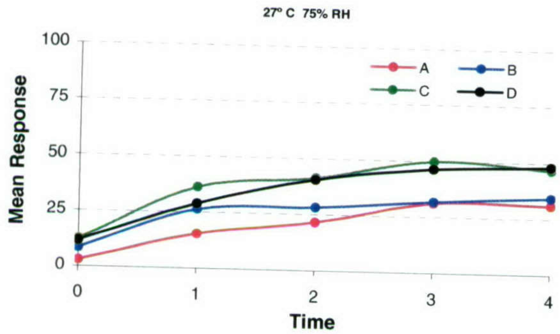
	Temp	Garment	Time 0	Time 1	Time 2	Time 3	Time 4	Overall	
Australian	81	A	3.60	6.31	9.91	15.17	15.47	10.09	Mean
			9	9	9	9	9	45	N
			6.48	8.05	12.55	14.46	15.93	12.45	St. Dev.
US Army Hot Weather BDU		B	15.17	12.91	16.22	16.22	18.77	15.86	
			9	9	9	9	9	45	
			17.28	12.86	16.02	13.91	19.45	15.45	
Canadian		C	18.02	20.12	29.43	30.33	31.98	25.98	
			9	9	9	9	9	45	
			19.61	18.27	25.35	28.18	23.12	22.86	
US Army Aviator BDU (Nomex)		D	26.13	26.13	29.73	31.98	29.58	28.71	
			9	9	9	9	9	45	
			19.30	18.55	16.47	15.14	18.58	17.01	
Australian	68	A	8.56	7.21	8.26	5.86	8.41	7.66	
			9	9	9	9	9	45	
			10.66	9.29	8.26	6.59	8.73	8.46	
US Army Hot Weather BDU		B	16.37	16.67	13.51	16.07	18.47	16.22	
			9	9	9	9	9	45	
			15.94	10.92	10.09	12.06	10.66	11.66	
Canadian		C	22.22	22.67	24.32	23.72	24.62	23.51	
			9	9	9	9	9	45	
			26.69	31.68	29.83	30.90	31.36	28.76	
US Army Aviator BDU (Nomex)		D	25.83	18.77	15.17	12.61	12.16	16.91	
			9	9	9	9	9	45	
			18.27	15.58	13.27	11.35	12.09	14.59	

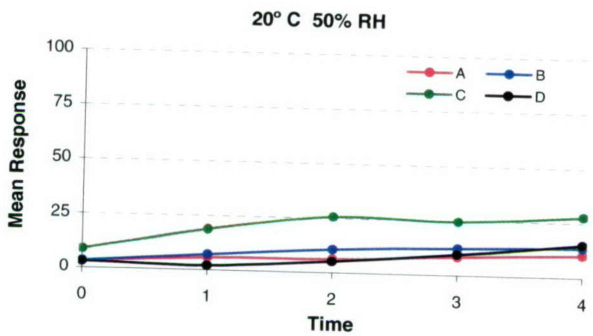




Seated Questionnaire: Question 1b
STICKY SENSATION (0 = Not at all, 100 = Extremely Strong)

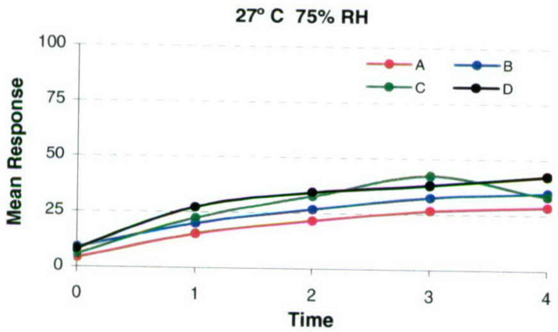
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	2.85	15.32	21.62	31.23	30.93	20.39	Mean
			9	9	9	9	9	45	N
			5.83	13.78	17.29	18.92	22.80	19.23	St. Dev.
US Army Hot Weather BDU		B	8.56	26.28	28.23	31.83	34.38	25.86	
			9	9	9	9	9	45	
			12.14	12.86	14.93	17.94	21.39	17.99	
Canadian		C	12.31	36.34	41.44	49.85	46.85	37.36	
			9	9	9	9	9	45	
			17.72	13.42	20.10	30.87	29.58	26.04	
US Army Aviator BDU (Nomex)		D	11.56	28.83	40.69	46.40	48.05	35.11	
			9	9	9	9	9	45	
			13.21	13.73	16.25	19.21	21.22	21.24	
Australian	68	A	3.15	5.71	6.31	8.56	10.36	6.82	
			9	9	9	9	9	45	
			4.17	6.61	8.44	8.57	10.38	7.95	
US Army Hot Weather BDU		B	3.45	7.21	10.66	12.46	13.66	9.49	
			9	9	9	9	9	45	
			6.62	10.34	10.54	12.64	13.81	11.20	
Canadian		C	8.86	18.62	25.53	24.47	27.78	21.05	
			9	9	9	9	9	45	
			12.42	25.48	22.30	22.91	28.23	22.89	
US Army Aviator BDU (Nomex)		D	3.00	1.95	5.26	9.61	15.02	6.97	
			9	9	9	9	9	45	
			5.84	4.54	5.38	8.40	16.47	10.05	

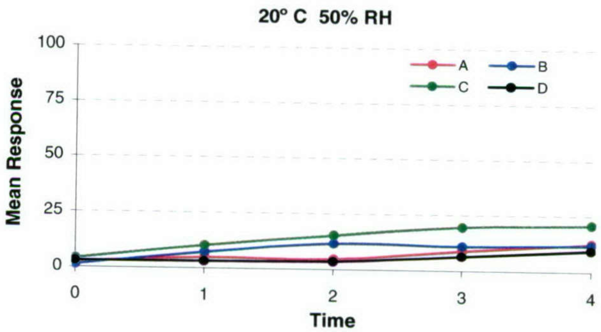




Seated Questionnaire: Question 1c
CLAMMY SENSATION (0 = Not at all, 100 = Extremely Strong)

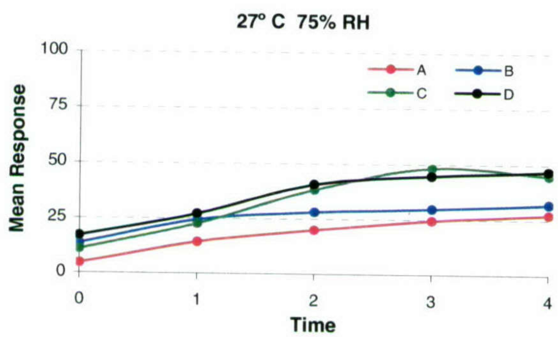
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	4.18	15.01	21.50	26.55	28.57	19.16	Mean
			9	9	9	9	9	45	N
			5.94	14.23	16.98	16.47	21.04	17.47	St. Dev.
US Army Hot Weather BDU	81	B	8.80	19.77	26.70	32.61	35.21	24.62	
			9	9	9	9	9	45	
			11.92	13.34	13.94	21.62	26.29	19.93	
Canadian	81	C	5.77	22.22	32.76	42.28	33.48	27.30	
			9	9	9	9	9	45	
			7.06	16.47	24.05	28.28	27.10	24.54	
US Army Aviator BDU (Nomex)	81	D	8.08	27.27	34.49	38.24	42.57	30.13	
			9	9	9	9	9	45	
			13.35	15.01	16.67	20.45	19.91	20.54	
Australian	68	A	2.60	4.91	4.76	9.09	12.84	6.84	
			9	9	9	9	9	45	
			4.45	8.36	6.72	9.16	12.85	9.14	
US Army Hot Weather BDU	68	B	1.30	7.36	11.69	11.26	12.12	8.74	
			9	9	9	9	9	45	
			3.44	10.53	12.99	14.15	13.64	11.85	
Canadian	68	C	4.18	10.39	15.44	19.62	20.92	14.11	
			9	9	9	9	9	45	
			9.36	15.84	20.11	23.04	26.12	19.87	
US Army Aviator BDU (Nomex)	68	D	3.03	3.17	3.75	6.64	9.81	5.28	
			9	9	9	9	9	45	
			8.16	3.12	3.76	6.54	11.99	7.57	

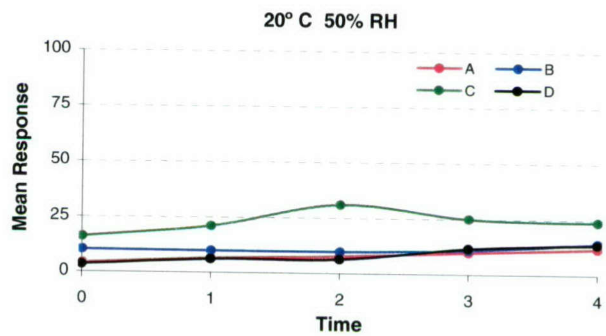




Seated Questionnaire: Question 1d
CLINGY SENSATION (0 = Not at all, 100 = Extremely Strong)

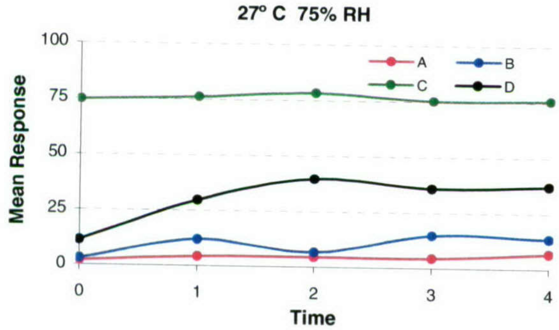
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	4.62	14.29	19.91	24.53	27.27	18.12	Mean
			9	9	9	9	9	45	N
			6.37	14.27	16.68	19.85	23.55	18.27	St. Dev.
US Army Hot Weather BDU		B	13.42	24.39	28.14	29.87	31.89	25.54	
			9	9	9	9	9	45	
			14.61	14.09	14.33	17.30	22.29	17.34	
Canadian		C	10.97	22.51	38.10	48.20	44.88	32.93	
			9	9	9	9	9	45	
			9.48	13.51	23.30	30.22	27.82	25.66	
US Army Aviator BDU (Nomex)		D	16.88	26.98	40.55	44.59	46.75	35.15	
			9	9	9	9	9	45	
			19.88	14.72	17.69	16.14	16.81	20.01	
Australian	68	A	4.04	6.49	7.65	9.81	11.69	7.94	
			9	9	9	9	9	45	
			6.86	9.50	9.12	10.41	13.10	9.91	
US Army Hot Weather BDU		B	10.25	9.96	9.81	10.97	14.14	11.02	
			9	9	9	9	9	45	
			21.58	10.61	10.02	11.62	13.41	13.54	
Canadian		C	16.02	20.92	31.02	24.96	23.81	23.35	
			9	9	9	9	9	45	
			23.59	24.28	29.95	24.60	22.97	24.54	
US Army Aviator BDU (Nomex)		D	3.46	6.06	6.35	11.54	13.71	8.23	
			9	9	9	9	9	45	
			6.46	7.52	10.05	11.22	14.59	10.61	

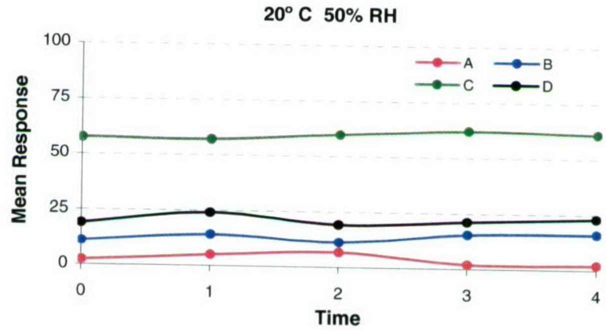




Seated Questionnaire: Question 1e
SCRATCHY SENSATION (0 = Not at all, 100 = Extremely Strong)

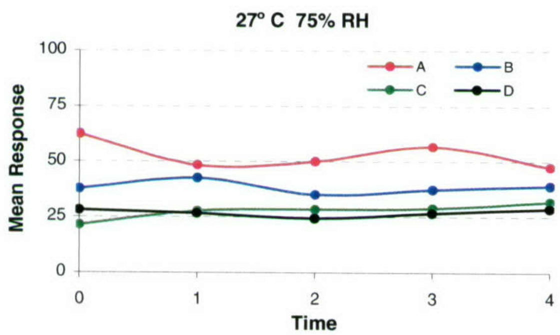
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	2.05	4.24	4.53	4.53	6.87	4.44	Mean
			9	9	9	9	9	45	N
			5.66	5.69	7.53	5.89	8.70	6.67	St. Dev.
US Army Hot Weather BDU		B	3.07	11.84	6.58	14.62	13.45	9.87	
			9	8	9	9	9	44	
			3.66	11.94	8.95	25.52	19.67	15.93	
Canadian		C	74.71	76.02	78.22	75.15	75.58	75.94	
			9	9	9	9	9	45	
			25.52	25.50	25.23	26.43	26.90	24.75	
US Army Aviator BDU (Nomex)		D	11.26	29.39	39.47	35.67	36.84	30.53	
			9	9	9	9	9	45	
			15.00	26.17	31.67	28.05	29.28	27.44	
Australian	68	A	2.34	4.97	6.73	2.05	2.19	3.65	
			9	9	9	9	9	45	
			3.53	6.16	8.28	3.36	3.42	5.42	
US Army Hot Weather BDU		B	10.96	14.18	11.26	15.50	15.94	13.57	
			9	9	9	9	9	45	
			13.94	12.34	9.65	12.91	11.35	11.75	
Canadian		C	57.46	57.16	59.80	61.99	61.11	59.50	
			9	9	9	9	9	45	
			33.11	31.57	31.91	31.67	32.18	30.66	
US Army Aviator BDU (Nomex)		D	18.86	23.98	19.15	21.05	22.95	21.20	
			9	9	9	9	9	45	
			22.44	27.43	22.18	26.18	26.97	24.06	

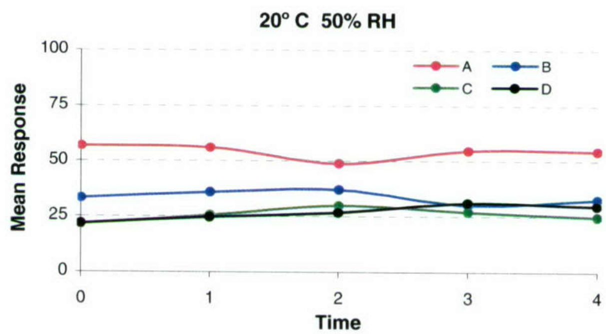




Seated Questionnaire: Question 1f
SOFT SENSATION (0 = Not at all, 100 = Extremely Strong)

	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	62.43	48.25	50.00	56.73	47.51	52.98	Mean
			9	9	9	9	9	45	N
			23.74	23.48	27.87	32.83	28.37	26.83	St. Dev.
US Army Hot Weather BDU		B	37.72	42.43	35.09	37.28	39.04	38.22	
			9	8	9	9	9	44	
			31.38	27.24	26.71	26.55	26.23	26.49	
Canadian		C	21.35	27.63	28.22	28.95	31.87	27.60	
			9	9	9	9	9	45	
			26.10	29.61	27.52	27.03	24.19	25.93	
US Army Aviator BDU (Nomex)		D	27.92	26.46	24.27	26.61	28.65	26.78	
			9	9	9	9	9	45	
			16.78	19.50	14.25	15.36	18.71	16.31	
Australian	68	A	56.73	55.99	48.83	54.68	54.39	54.12	
			9	9	9	9	9	45	
			31.78	28.83	30.18	31.64	31.35	29.48	
US Army Hot Weather BDU		B	33.19	35.82	37.13	30.12	32.60	33.77	
			9	9	9	9	9	45	
			25.19	25.14	27.39	25.35	24.55	24.48	
Canadian		C	21.49	25.44	29.68	26.90	24.71	25.64	
			9	9	9	9	9	45	
			23.88	28.07	29.06	27.21	25.86	25.77	
US Army Aviator BDU (Nomex)		D	21.78	24.56	26.61	30.99	29.53	26.70	
			9	9	9	9	9	45	
			14.65	17.08	14.32	16.81	15.19	15.30	

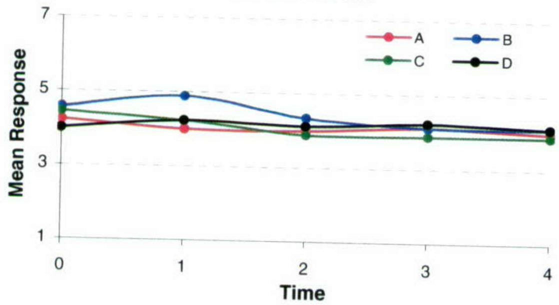


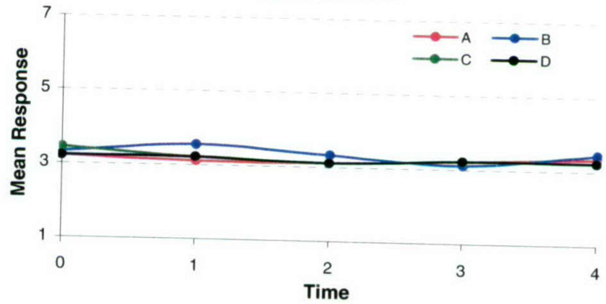


Note Subject III (make-up) rated this question incorrectly during testing. This data is not included.

Seated Questionnaire: Question 2
Air quality (1 = VERY FRESH, 7 = VERY STALE)

	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	4.22	4.00	4.00	4.11	4.00	4.07	Mean
			9	9	9	9	9	45	N
			1.56	1.41	1.41	1.45	1.41	1.39	St. Dev.
US Army Hot Weather BDU		B	4.56	4.88	4.33	4.11	4.11	4.39	
			9	8	9	9	9	44	
			1.24	0.99	1.22	1.27	1.27	1.19	
Canadian		C	4.44	4.22	3.89	3.89	3.89	4.07	
			9	9	9	9	9	45	
			1.24	1.48	1.45	1.45	1.45	1.37	
US Army Aviator BDU (Nomex)		D	4.00	4.22	4.11	4.22	4.11	4.13	
			9	9	9	9	9	45	
			1.50	1.09	1.05	1.09	1.05	1.12	
Australian	68	A	3.22	3.11	3.11	3.22	3.33	3.20	
			9	9	9	9	9	45	
			1.39	1.36	1.17	1.30	1.32	1.25	
US Army Hot Weather BDU		B	3.33	3.56	3.33	3.11	3.44	3.36	
			9	9	9	9	9	45	
			1.66	1.51	1.66	1.54	1.59	1.52	
Canadian		C	3.44	3.22	3.11	3.22	3.22	3.24	
			9	9	9	9	9	45	
			1.67	1.30	1.27	1.30	1.30	1.32	
US Army Aviator BDU (Nomex)		D	3.22	3.22	3.11	3.22	3.22	3.20	
			9	9	9	9	9	45	
			1.20	1.39	1.36	1.30	1.30	1.25	

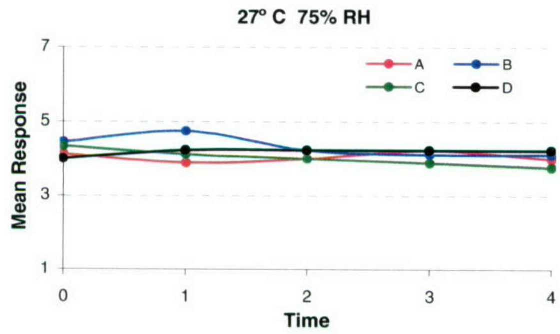


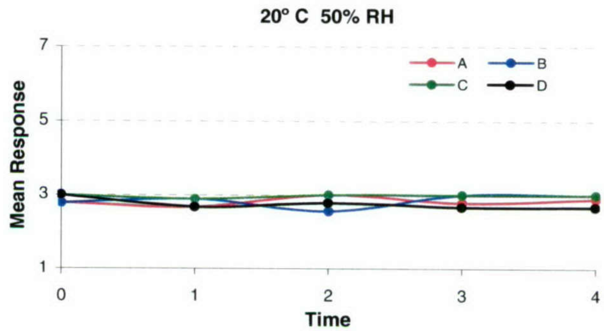


Note Subject III (make-up) did not answer this question for the time/conditions indicated.

Seated Questionnaire: Question 3
Air Quality (1 = Very PLEASANT, 7 = Very UNPLEASANT)

	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	4.11	3.89	4.00	4.22	4.00	4.04	Mean
			9	9	9	9	9	45	N
			1.45	1.27	1.41	1.56	1.41	1.36	St. Dev.
US Army Hot Weather BDU		B	4.44	4.75	4.22	4.11	4.11	4.32	
			9	8	9	9	9	44	
			1.24	1.04	1.48	1.62	1.45	1.34	
Canadian		C	4.33	4.11	4.00	3.89	3.78	4.02	
			9	9	9	9	9	45	
			1.12	1.17	1.41	1.45	1.39	1.27	
US Army Aviator BDU (Nomex)		D	4.00	4.22	4.22	4.22	4.22	4.18	
			9	9	9	9	9	45	
			1.32	0.97	0.97	1.09	0.97	1.03	
Australian	68	A	2.78	2.67	3.00	2.78	2.89	2.82	
			9	9	9	9	9	45	
			1.30	1.22	1.22	1.20	1.27	1.19	
US Army Hot Weather BDU		B	2.78	2.89	2.56	3.00	3.00	2.84	
			9	9	9	9	9	45	
			1.39	1.27	1.13	1.22	1.32	1.22	
Canadian		C	3.00	2.89	3.00	3.00	3.00	2.98	
			9	9	9	9	9	45	
			1.12	1.05	1.12	1.12	1.12	1.06	
US Army Aviator BDU (Nomex)		D	3.00	2.67	2.78	2.67	2.67	2.76	
			9	9	9	9	9	45	
			1.22	1.32	1.30	1.22	1.32	1.23	

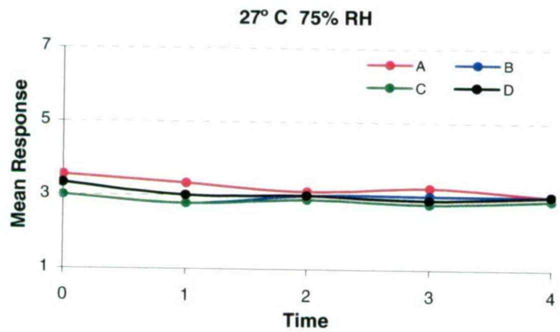


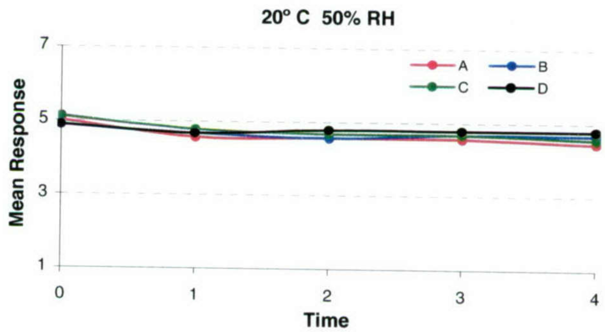


Note Subject III (make-up) did not answer this question for the time/conditions indicated.

Seated Questionnaire: Question 4
Air Temperature (1 = Very HOT, 7 = Very COLD)

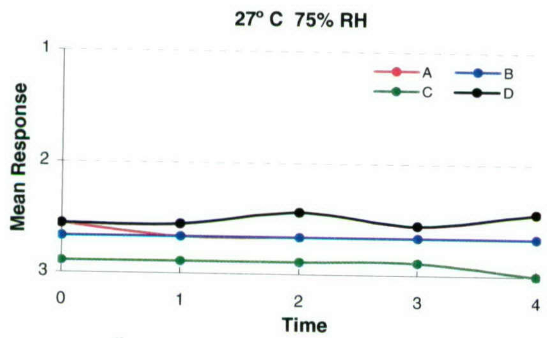
	Temp	Garment		Time 0	1	2	3	4	Overall
Australian	81	A	Mean	3.56	3.33	3.11	3.22	3.00	3.24
			N	9	9	9	9	9	45
			St. Dev.	0.53	0.50	0.33	0.67	0.71	0.57
US Army Hot Weather BDU		B	Mean	3.00	2.78	3.00	3.00	3.00	2.96
			N	9	9	9	9	9	45
			St. Dev.	0.50	0.44	0.50	0.50	0.50	0.47
Canadian		C	Mean	3.00	2.78	2.89	2.78	2.89	2.87
			N	9	9	9	9	9	45
			St. Dev.	0.00	0.44	0.60	0.44	0.60	0.46
US Army Aviator BDU (Nomex)		D	Mean	3.33	3.00	3.00	2.89	3.00	3.04
			N	9	9	9	9	9	45
			St. Dev.	0.87	0.50	0.50	0.60	0.50	0.60
Australian	68	A	Mean	5.00	4.56	4.56	4.56	4.44	4.62
			N	9	9	9	9	9	45
			St. Dev.	0.50	0.73	0.53	0.53	0.53	0.58
US Army Hot Weather BDU		B	Mean	4.89	4.67	4.56	4.67	4.67	4.69
			N	9	9	9	9	9	45
			St. Dev.	0.33	0.50	0.53	0.50	0.50	0.47
Canadian		C	Mean	5.11	4.78	4.67	4.67	4.56	4.76
			N	9	9	9	9	9	45
			St. Dev.	0.33	0.44	0.50	0.50	0.53	0.48
US Army Aviator BDU (Nomex)		D	Mean	4.89	4.67	4.78	4.78	4.78	4.78
			N	9	9	9	9	9	45
			St. Dev.	0.33	0.50	0.44	0.44	0.44	0.42

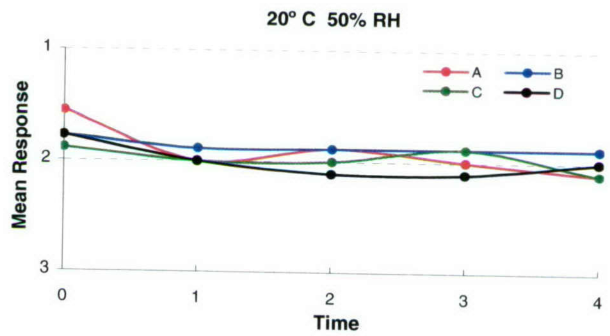




Seated Questionnaire: Question 5
Preferred Temperature (1 = WARMER, 2 = NO CHANGE, 3 = COLDER)

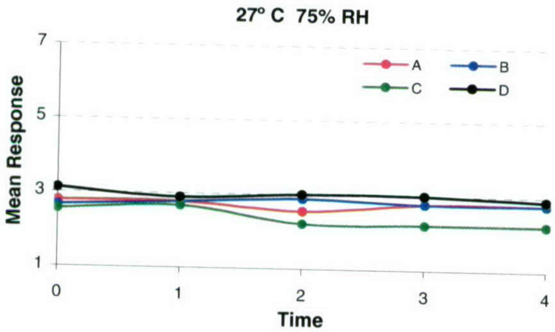
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	2.56	2.67	2.67	2.67	2.67	2.64	Mean
			9	9	9	9	9	45	N
			0.53	0.50	0.50	0.50	0.50	0.48	St. Dev.
US Army Hot Weather BDU		B	2.67	2.67	2.67	2.67	2.67	2.67	
			9	9	9	9	9	45	
			0.71	0.50	0.50	0.50	0.50	0.52	
Canadian		C	2.89	2.89	2.89	2.89	3.00	2.91	
			9	9	9	9	9	45	
			0.33	0.33	0.33	0.33	0.00	0.29	
US Army Aviator BDU (Nomex)		D	2.56	2.56	2.44	2.56	2.44	2.51	
			9	9	9	9	9	45	
			0.53	0.53	0.53	0.53	0.53	0.51	
Australian	68	A	1.56	2.00	1.89	2.00	2.11	1.91	
			9	9	9	9	9	45	
			0.53	0.50	0.60	0.50	0.33	0.51	
US Army Hot Weather BDU		B	1.78	1.89	1.89	1.89	1.89	1.87	
			9	9	9	9	9	45	
			0.44	0.33	0.33	0.33	0.33	0.34	
Canadian		C	1.89	2.00	2.00	1.89	2.11	1.98	
			9	9	9	9	9	45	
			0.60	0.50	0.50	0.60	0.33	0.50	
US Army Aviator BDU (Nomex)		D	1.78	2.00	2.11	2.11	2.00	2.00	
			9	9	9	9	9	45	
			0.44	0.50	0.33	0.33	0.50	0.43	

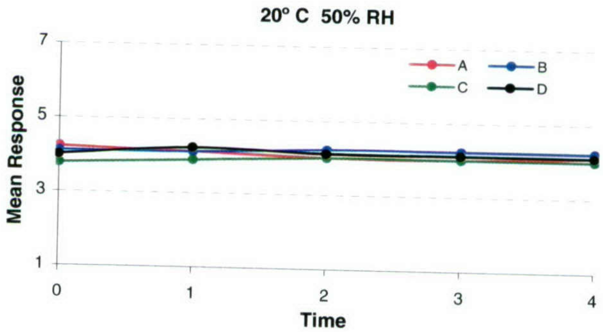




Seated Questionnaire: Question 6
Humidity (1 = Very HUMID, 7 = Very DRY)

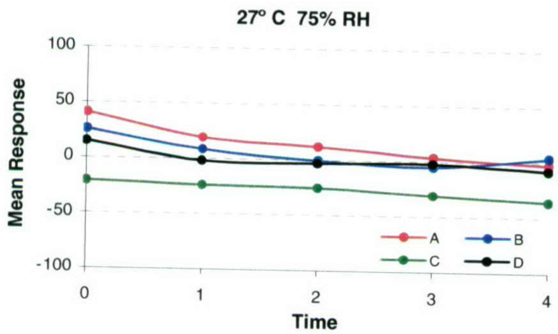
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	2.78	2.78	2.56	2.78	2.78	2.73	Mean
			9	9	9	9	9	45	N
			1.20	1.20	1.13	1.20	1.20	1.14	St. Dev.
US Army Hot Weather BDU		B	2.67	2.78	2.89	2.78	2.78	2.78	
			9	9	9	9	9	45	
			1.41	1.48	1.54	1.48	1.48	1.41	
Canadian		C	2.56	2.67	2.22	2.22	2.22	2.38	
			9	9	9	9	9	45	
			1.13	1.12	0.83	0.67	0.67	0.89	
US Army Aviator BDU (Nomex)		D	3.11	2.89	3.00	3.00	2.89	2.98	
			9	9	9	9	9	45	
			1.62	1.36	1.32	1.32	1.27	1.32	
Australian	68	A	4.22	4.11	4.00	4.00	4.11	4.09	
			9	9	9	9	9	45	
			0.97	0.93	0.87	1.00	0.60	0.85	
US Army Hot Weather BDU		B	4.11	4.11	4.22	4.22	4.22	4.18	
			9	9	9	9	9	45	
			0.78	0.78	0.83	0.97	0.97	0.83	
Canadian		C	3.78	3.89	4.00	4.00	4.00	3.93	
			9	9	9	9	9	45	
			0.83	0.60	0.50	0.50	0.50	0.58	
US Army Aviator BDU (Nomex)		D	4.00	4.22	4.11	4.11	4.11	4.11	
			9	9	9	9	9	45	
			1.41	1.30	1.05	1.05	1.05	1.13	

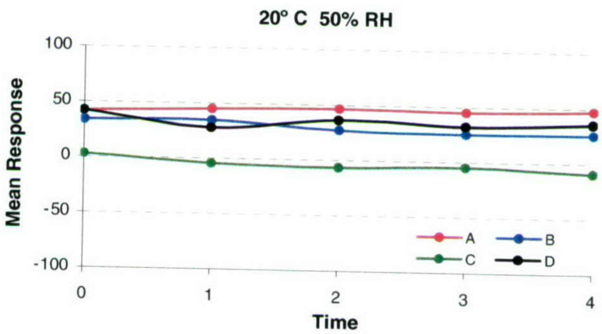




Seated Questionnaire: Question 7
Comfort (-100 = Greatest Imaginable Discomfort, 100 = Greatest Imaginable Comfort)

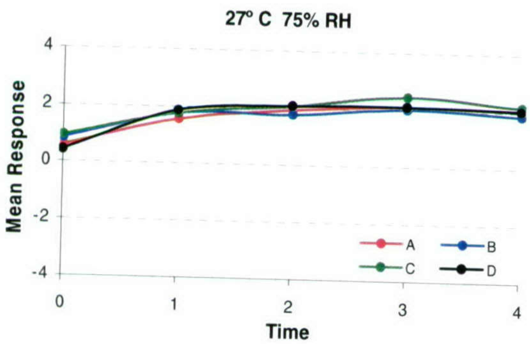
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	40.64	19.01	11.99	3.51	-2.34	14.56	Mean
			9	9	9	9	9	45	N
			33.26	45.33	50.54	44.33	44.24	44.50	St. Dev.
US Army Hot Weather BDU		B	26.02	8.19	-0.58	-4.97	4.09	6.55	
			9	9	9	9	9	45	
			30.84	44.75	41.46	47.92	45.11	41.88	
Canadian		C	-20.76	-23.68	-25.15	-30.70	-35.67	-27.19	
			9	9	9	9	9	45	
			41.03	46.61	48.44	51.03	48.22	45.31	
US Army Aviator BDU (Nomex)		D	14.91	-2.05	-3.22	-2.34	-7.60	-0.06	
			9	9	9	9	9	45	
			28.04	32.22	35.57	36.52	40.59	34.13	
Australian	68	A	42.11	44.74	46.49	45.03	47.37	45.15	
			9	9	9	9	9	45	
			37.45	30.77	29.77	32.16	29.92	30.70	
US Army Hot Weather BDU		B	33.92	34.50	27.19	25.15	26.02	29.36	
			9	9	9	9	9	45	
			26.75	28.75	30.06	27.64	26.92	27.05	
Canadian		C	2.92	-4.39	-6.73	-4.68	-9.06	-4.39	
			9	9	9	9	9	45	
			36.97	51.25	51.87	51.51	51.35	46.84	
US Army Aviator BDU (Nomex)		D	42.11	27.78	36.26	32.16	35.38	34.74	
			9	9	9	9	9	45	
			24.44	32.66	27.34	31.38	36.77	29.77	

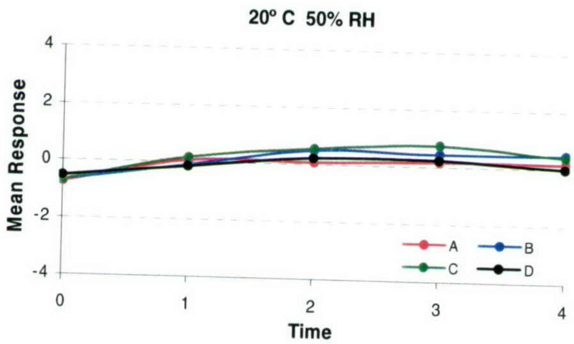




Seated Questionnaire: Question 8
How hot or cold does your body feel? (-4 = Very COLD, 4 = Very HOT)

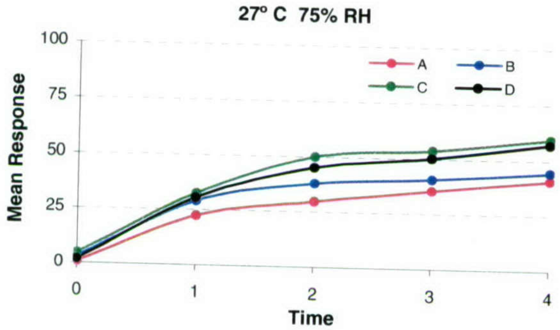
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	0.57	1.54	1.93	2.12	2.06	1.64	Mean
			9	9	9	9	9	45	N
			0.68	0.86	0.54	0.45	0.49	0.83	St. Dev.
US Army Hot Weather BDU		B	0.83	1.77	1.78	2.02	1.85	1.65	
			9	9	9	9	9	45	
			0.92	0.88	0.78	0.68	0.72	0.87	
Canadian		C	0.92	1.75	2.07	2.44	2.16	1.87	
			9	9	9	9	9	45	
			1.07	0.77	0.83	0.73	0.67	0.95	
US Army Aviator BDU (Nomex)		D	0.41	1.86	2.08	2.12	2.04	1.70	
			9	9	9	9	9	45	
			0.88	0.82	0.73	0.49	0.76	0.97	
Australian	68	A	-0.75	0.06	0.07	0.16	0.16	-0.06	
			9	9	9	9	9	45	
			0.83	0.82	0.75	0.67	0.86	0.83	
US Army Hot Weather BDU		B	-0.69	-0.09	0.50	0.44	0.48	0.13	
			9	9	9	9	9	45	
			0.61	0.76	0.61	0.51	0.28	0.72	
Canadian		C	-0.70	0.16	0.56	0.75	0.40	0.23	
			9	9	9	9	9	45	
			0.71	0.75	0.79	1.04	0.94	0.96	
US Army Aviator BDU (Nomex)		D	-0.54	-0.15	0.22	0.23	0.00	-0.05	
			9	9	9	9	9	45	
			0.58	0.89	0.79	0.85	0.68	0.78	

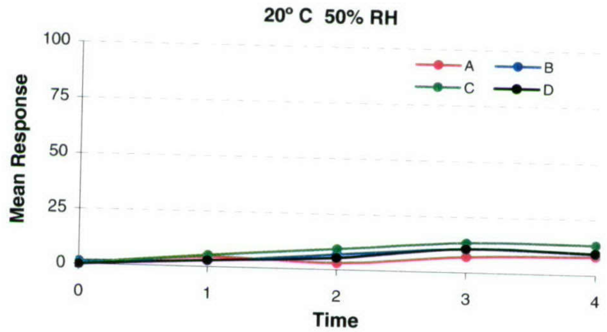




Seated Questionnaire: Question 9
SWEATY SENSATION (0 = Not at all, 100 = Extremely Strong)

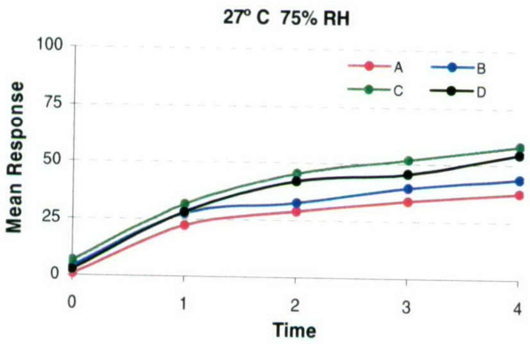
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	0.89	22.37	29.63	35.26	40.74	25.78	Mean
			9	9	9	9	9	45	N
			1.89	14.95	13.25	15.17	19.43	19.49	St. Dev.
US Army Hot Weather BDU		B	3.26	29.04	37.78	40.59	44.44	31.02	
			9	9	9	9	9	45	
			5.66	5.69	11.04	10.92	15.49	17.96	
Canadian		C	4.89	32.44	49.93	53.48	59.26	40.00	
			9	9	9	9	9	45	
			8.30	9.24	18.11	20.85	22.70	25.64	
US Army Aviator BDU (Nomex)		D	1.93	30.37	45.04	50.22	56.89	36.89	
			9	9	9	9	9	45	
			2.50	6.32	13.50	15.92	18.46	23.24	
Australian	68	A	0.30	4.30	2.96	6.96	8.15	4.53	
			9	9	9	9	9	45	
			0.89	4.84	2.96	7.68	11.84	7.09	
US Army Hot Weather BDU		B	1.48	2.81	6.67	10.37	9.33	6.13	
			9	9	9	9	9	45	
			3.97	6.48	8.03	9.33	9.61	8.21	
Canadian		C	0.59	5.19	9.19	13.33	13.33	8.33	
			9	9	9	9	9	45	
			1.35	5.31	11.00	15.26	15.13	11.67	
US Army Aviator BDU (Nomex)		D	0.00	2.81	5.33	10.52	9.48	5.63	
			9	9	9	9	9	45	
			0.00	2.44	6.07	11.78	11.02	8.44	

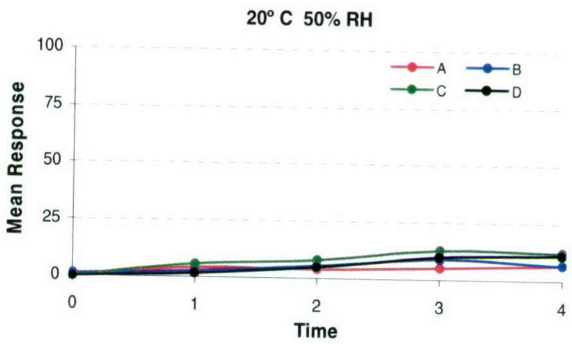




Seated Questionnaire: Question 10
WET SKIN SENSATION (0 = Not at all, 100 = Extremely Strong)

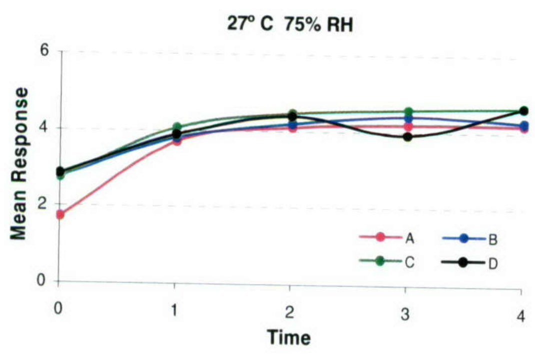
	Temp	Garment	Time 0	1	2	3	4	Overall	
Australian	81	A	0.74	22.22	28.89	33.78	37.63	24.65	Mean
			9	9	9	9	9	45	N
			1.78	17.73	12.18	17.28	19.31	19.50	St. Dev.
US Army Hot Weather BDU		B	4.30	27.41	32.59	39.56	43.85	29.54	
			9	9	9	9	9	45	
			10.54	10.39	13.27	11.66	12.62	17.92	
Canadian		C	6.67	31.41	45.33	51.85	58.22	38.70	
			9	9	9	9	9	45	
			13.23	14.27	20.49	25.33	24.59	26.74	
US Army Aviator BDU (Nomex)		D	2.81	28.00	42.07	45.63	54.67	34.64	
			9	9	9	9	9	45	
			6.58	8.11	16.73	11.41	17.04	21.94	
Australian	68	A	0.15	4.30	4.15	5.33	6.81	4.15	
			9	9	9	9	9	45	
			0.44	7.14	6.71	7.02	9.41	6.90	
US Army Hot Weather BDU		B	1.33	2.96	5.63	9.04	6.81	5.16	
			9	9	9	9	9	45	
			4.00	6.46	6.52	9.11	9.83	7.65	
Canadian		C	0.15	5.93	8.15	12.89	12.30	7.88	
			9	9	9	9	9	45	
			0.44	7.09	9.94	16.52	17.97	12.56	
US Army Aviator BDU (Nomex)		D	0.00	1.78	5.04	10.07	11.26	5.63	
			9	9	9	9	9	45	
			0.00	2.21	6.46	13.23	20.26	11.62	

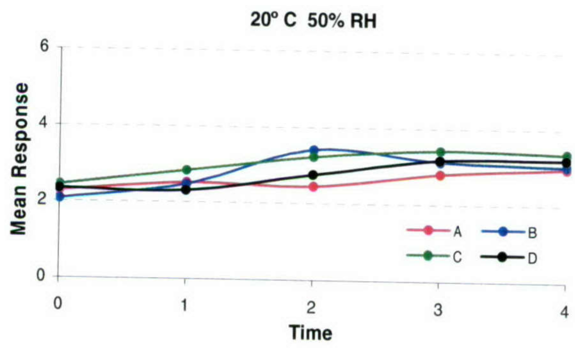




Seated Questionnaire: Question 11
How wet or dry does your skin feel? (0 = Very DRY, 6 = SOAKING/DRIPPING WET)

	Temp	Garment	0	1	2	3	4	Overall	
Australian	81	A	1.73	3.71	4.10	4.20	4.20	3.59	Mean
			9	9	9	9	9	45	N
			1.36	0.59	0.39	0.57	0.68	1.22	St. Dev.
US Army Hot Weather BDU		B	2.78	3.80	4.20	4.40	4.26	3.89	
			9	9	9	9	9	45	
			0.54	0.42	0.43	0.54	0.43	0.75	
Canadian		C	2.76	4.07	4.45	4.58	4.66	4.10	
			9	9	9	9	9	45	
			0.81	0.59	0.56	0.54	0.65	0.94	
US Army Aviator BDU (Nomex)		D	2.85	3.88	4.38	3.92	4.65	3.94	
			9	9	9	9	9	45	
			0.59	0.34	0.44	1.36	0.60	0.95	
Australian	68	A	2.28	2.52	2.45	2.80	2.97	2.60	
			9	9	9	9	9	45	
			1.05	1.03	0.98	1.10	0.64	0.96	
US Army Hot Weather BDU		B	2.07	2.49	3.41	3.13	3.03	2.83	
			9	9	9	9	9	45	
			1.13	0.91	1.05	0.47	0.52	0.95	
Canadian		C	2.44	2.84	3.22	3.42	3.36	3.06	
			9	9	9	9	9	45	
			0.98	0.26	0.57	0.74	0.70	0.76	
US Army Aviator BDU (Nomex)		D	2.35	2.31	2.76	3.16	3.20	2.76	
			9	9	9	9	9	45	
			1.09	1.10	1.11	0.70	0.59	0.98	

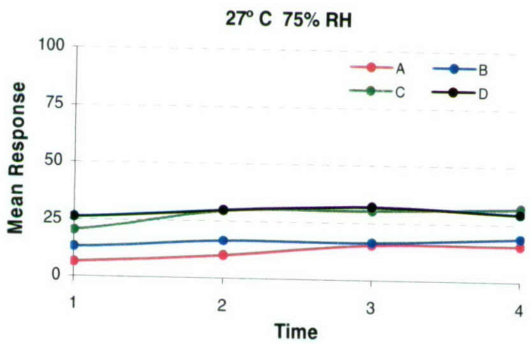


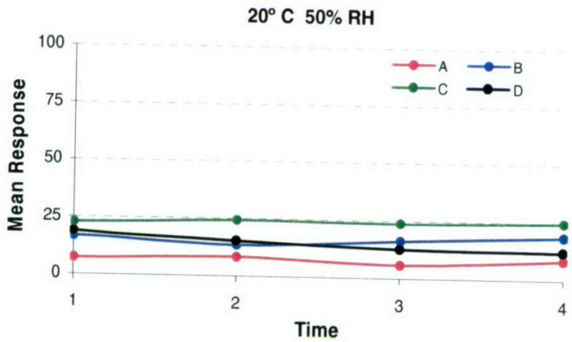


Appendix G
Results – Walking Questionnaire

Walking Questionnaire: Question 1
Rate the AMOUNT OF EFFORT you expended (0 = Not at all, 100 = Extremely Strong)

	Temp	Garment	Time 1	2	3	4	Overall	
Australian	81	A	22.52	29.73	27.48	28.08	26.95	Mean
			9	9	9	9	36	N
			11.20	11.08	10.25	9.83	10.50	St. Dev.
US Army Hot Weather BDU		B	24.92	29.13	27.18	29.73	27.74	
			9	9	9	9	36	
			9.19	10.29	10.05	11.66	10.07	
Canadian		C	27.53	30.18	30.93	32.13	30.27	
			8	9	9	9	35	
			12.17	2.62	6.46	6.47	7.39	
US Army Aviator BDU (Nomex)		D	20.57	23.87	27.03	27.78	24.81	
			9	9	9	9	36	
			13.58	12.68	10.66	10.43	11.75	
Australian	68	A	19.82	19.82	18.17	21.17	19.74	
			9	9	9	9	36	
			9.01	9.88	10.66	12.91	10.30	
US Army Hot Weather BDU		B	26.43	26.73	27.48	26.88	26.88	
			9	9	9	9	36	
			10.54	8.49	5.23	5.98	7.51	
Canadian		C	19.67	21.47	20.42	22.22	20.95	
			9	9	9	9	36	
			10.58	10.59	9.59	9.79	9.75	
US Army Aviator BDU (Nomex)		D	19.67	23.42	25.08	24.62	23.20	
			9	9	9	9	36	
			8.89	10.07	9.53	9.26	9.29	

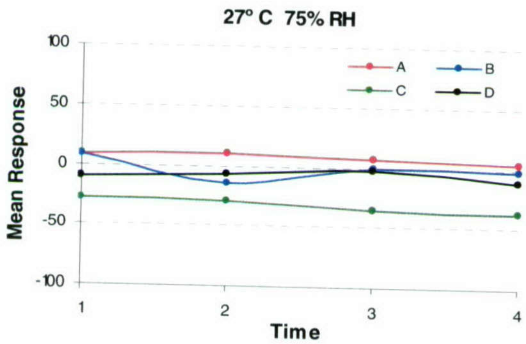


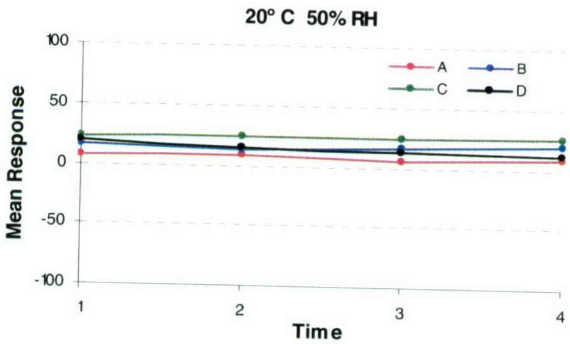


Note Subject 7 left chamber during 1st walking cycle. Missed walking questionnaire.

Walking Questionnaire: Question 2
COMFORT (-100 = Greatest Imaginable Discomfort, 100 = Greatest Imaginable Comfort)

	Temp	Garment	Time 1	Time 2	Time 3	Time 4	Overall	
Australian	81	A	8.07	10.50	7.46	3.20	7.31	Mean
			9	9	9	9	36	N
			38.29	43.19	39.98	44.07	39.72	St. Dev.
US Army Hot Weather BDU	81	B	8.68	-13.85	-0.46	-2.59	-2.05	
			9	9	9	9	36	
			38.55	47.73	40.78	40.89	41.10	
Canadian	81	C	-28.77	-29.98	-35.77	-36.99	-32.99	
			8	9	9	9	35	
			42.72	47.79	45.39	52.40	45.35	
US Army Aviator BDU (Nomex)	81	D	-9.28	-7.15	-2.28	-10.81	-7.38	
			9	9	9	9	36	
			32.20	35.73	37.29	32.62	33.17	
Australian	68	A	45.81	40.33	40.33	41.25	41.93	
			9	9	9	9	36	
			30.35	33.91	31.50	30.36	30.27	
US Army Hot Weather BDU	68	B	30.59	24.20	28.46	23.29	26.64	
			9	9	9	9	36	
			22.05	24.88	23.14	27.94	23.72	
Canadian	68	C	-10.81	-5.63	-5.33	-7.46	-7.31	
			9	9	9	9	36	
			35.67	50.52	51.13	51.58	45.66	
US Army Aviator BDU (Nomex)	68	D	27.55	14.76	23.59	33.33	24.81	
			9	9	9	9	36	
			25.19	36.49	31.52	37.64	32.36	

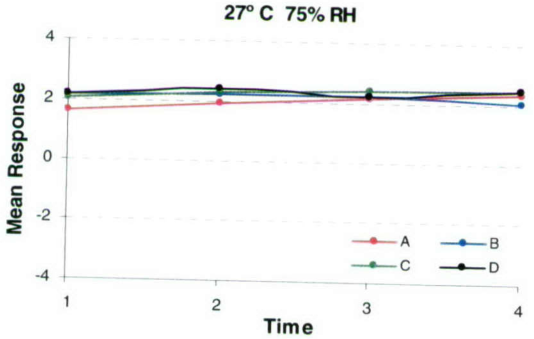


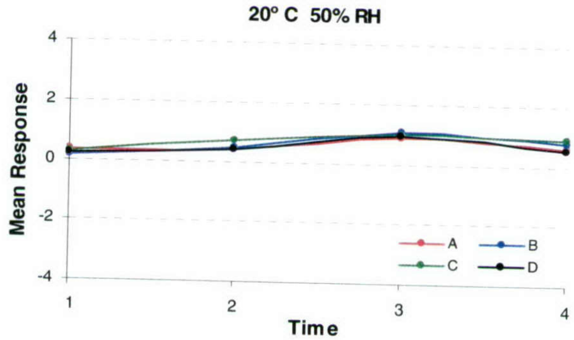


Note Subject 7 left chamber during 1st walking cycle. Missed walking questionnaire.

Walking Questionnaire: Question 3
How HOT or COLD does your body feel? (-4 = Very Cold, 4 = Very Hot)

	Temp	Garment	Time 1	Time 2	Time 3	Time 4	Overall	
Australian	81	A	1.63	1.91	2.19	2.34	2.02	Mean
			9	9	9	9	36	N
			0.73	0.76	0.34	0.44	0.63	St. Dev.
US Army Hot Weather BDU	81	B	2.18	2.25	2.22	2.03	2.17	
			9	9	9	9	36	
			0.64	0.64	0.80	0.66	0.67	
Canadian	81	C	2.04	2.31	2.42	2.48	2.32	
			8	9	9	9	35	
			0.70	0.55	0.64	0.63	0.63	
US Army Aviator BDU (Nomex)	81	D	2.19	2.42	2.23	2.49	2.33	
			9	9	9	9	36	
			0.29	0.59	0.47	0.66	0.51	
Australian	68	A	0.35	0.39	0.88	0.57	0.55	
			9	9	9	9	36	
			0.83	0.58	0.60	0.74	0.70	
US Army Hot Weather BDU	68	B	0.14	0.43	1.06	0.76	0.60	
			9	9	9	9	36	
			0.69	0.49	0.46	0.78	0.68	
Canadian	68	C	0.26	0.69	1.01	0.89	0.71	
			9	9	9	9	36	
			0.90	0.63	0.30	0.84	0.74	
US Army Aviator BDU (Nomex)	68	D	0.24	0.42	0.92	0.54	0.53	
			9	9	9	9	36	
			1.01	0.70	0.87	0.85	0.86	

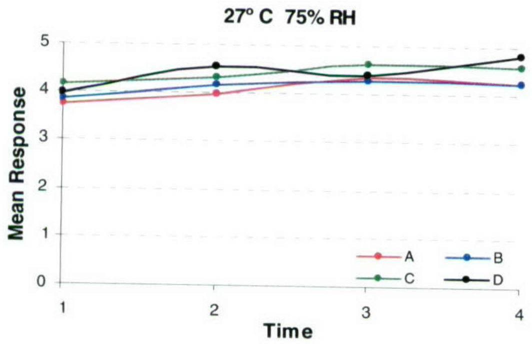


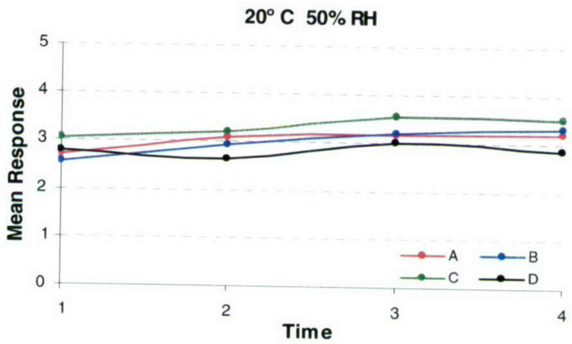


Note Subject 7 left chamber during 1st walking cycle. Missed walking questionnaire.

Walking Questionnaire: Question 4
How WET or DRY does your skin feel? (0 = Very Dry, 6 = Soaking/ Dripping Wet)

	Temp	Garment	Time 1	Time 2	Time 3	Time 4	Overall	
Australian	81	A	3.73	3.96	4.34	4.23	4.06	Mean
			9	9	9	9	36	N
			0.42	0.84	0.42	0.41	0.58	St. Dev.
US Army Hot Weather BDU	81	B	3.87	4.16	4.28	4.24	4.14	
			9	9	9	9	36	
			0.26	0.36	0.53	0.44	0.42	
Canadian	81	C	4.15	4.32	4.63	4.59	4.43	
			8	9	9	9	35	
			0.29	0.56	0.52	0.63	0.54	
US Army Aviator BDU (Nomex)	81	D	3.97	4.55	4.39	4.81	4.43	
			9	9	9	9	36	
			0.45	0.62	0.51	0.66	0.62	
Australian	68	A	2.70	3.09	3.19	3.21	3.05	
			9	9	9	9	36	
			0.53	0.14	0.49	0.67	0.52	
US Army Hot Weather BDU	68	B	2.57	2.94	3.21	3.32	3.01	
			9	9	9	9	36	
			0.72	0.93	0.82	0.43	0.77	
Canadian	68	C	3.05	3.22	3.53	3.50	3.32	
			9	9	9	9	36	
			0.06	0.46	0.67	0.69	0.55	
US Army Aviator BDU (Nomex)	68	D	2.81	2.62	3.02	2.85	2.82	
			9	9	9	9	36	
			0.65	1.21	0.83	0.80	0.87	

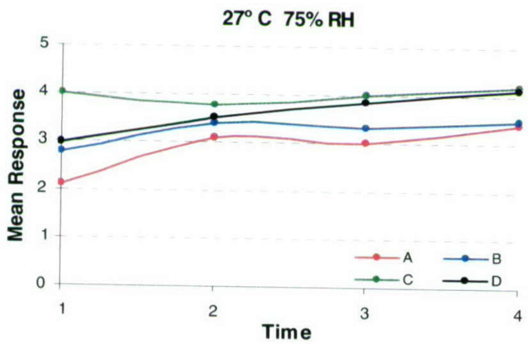


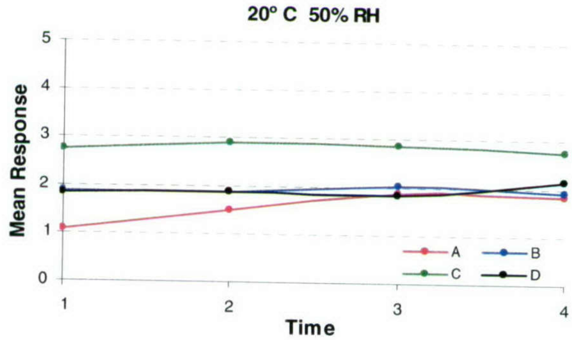


Note Subject 7 left chamber during 1st walking cycle. Missed walking questionnaire.

Walking Questionnaire: Question 5
Rate the CLOTHING/SKIN CONTACT sensation. (0=None/Very Slippery, 6=Very Sticky)

	Temp	Garment	Time 1	Time 2	Time 3	Time 4	Overall	
Australian	81	A	2.10	3.11	3.00	3.40	2.90	Mean
			9	9	9	9	36	N
			1.21	0.89	1.36	1.50	1.30	St. Dev.
US Army Hot Weather BDU	81	B	2.78	3.40	3.31	3.46	3.24	
			9	9	9	9	36	
			0.84	0.70	0.84	0.59	0.77	
Canadian	81	C	4.02	3.79	4.01	4.20	4.01	
			8	9	9	9	35	
			0.86	1.66	1.62	1.73	1.46	
US Army Aviator BDU (Nomex)	81	D	2.97	3.52	3.86	4.13	3.62	
			9	9	9	9	36	
			1.56	1.37	0.80	0.90	1.23	
Australian	68	A	1.06	1.50	1.87	1.82	1.56	
			9	9	9	9	36	
			1.00	1.17	1.10	1.18	1.11	
US Army Hot Weather BDU	68	B	1.88	1.89	2.03	1.91	1.93	
			9	9	9	9	36	
			1.30	1.35	1.45	1.25	1.28	
Canadian	68	C	2.75	2.91	2.87	2.74	2.82	
			9	9	9	9	36	
			1.54	1.64	1.42	1.44	1.45	
US Army Aviator BDU (Nomex)	68	D	1.83	1.86	1.84	2.12	1.91	
			9	9	9	9	36	
			1.22	1.23	1.31	1.22	1.20	





Note Subject 7 left chamber during 1st walking cycle. Missed walking questionnaire.

Appendix H
Summary Statistics – Results for Seated Subjects

Seated - Stiff Sensation

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	1501.177	1	1501.177	3.894	.084
Error(ENV_COND)	3084.196	8	385.524		
GARMENT	14012.682	3	4670.894	2.597	.076
Error(GARMENT)	43157.972	24	1798.249		
TIME	613.150	4	153.288	1.229	.318
Error(TIME)	3990.392	32	124.700		
ENV_COND * GARMENT	1905.162	3	635.054	1.827	.169
Error(ENV_COND*GARMENT)	8343.286	24	347.637		
ENV_COND * TIME	1836.164	4	459.041	8.651	.000
Error(ENV_COND*TIME)	1697.985	32	53.062		
GARMENT * TIME	1247.900	12	103.992	1.683	.082
Error(GARMENT*TIME)	5930.880	96	61.780		
ENV_COND * GARMENT * TIME	519.408	12	43.284	1.134	.342
Error(ENV_COND*GARMENT*TIME)	3663.755	96	38.164		

Seated - Sticky Sensation

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	31123.331	1	31123.331	46.965	.000
Error(ENV_COND)	5301.568	8	662.696		
GARMENT	11839.152	3	3946.384	4.938	.008
Error(GARMENT)	19181.347	24	799.223		
TIME	21909.971	4	5477.493	30.890	.000
Error(TIME)	5674.306	32	177.322		
ENV_COND * GARMENT	2846.050	3	948.683	2.971	.052
Error(ENV_COND*GARMENT)	7663.126	24	319.297		
ENV_COND * TIME	5245.698	4	1311.425	12.457	.000
Error(ENV_COND*TIME)	3368.893	32	105.278		
GARMENT * TIME	1349.992	12	112.499	1.372	.193
Error(GARMENT*TIME)	7873.985	96	82.021		
ENV_COND * GARMENT * TIME	607.479	12	50.623	.794	.655
Error(ENV_COND*GARMENT*TIME)	6120.151	96	63.752		

Seated - Clammy Sensation

Tests of Within-Subjects Effects

Measure: MEASURE_1

Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	24676.379	1	24676.379	36.301	.000
Error(ENV_COND)	5438.185	8	679.773		
GARMENT	2729.536	3	909.845	1.497	.241
Error(GARMENT)	14588.014	24	607.834		
TIME	18657.371	4	4664.343	19.735	.000
Error(TIME)	7563.323	32	236.354		
ENV_COND * GARMENT	2215.902	3	738.634	2.686	.069
Error(ENV_COND*GARMENT)	6601.057	24	275.044		
ENV_COND * TIME	4315.511	4	1078.878	12.579	.000
Error(ENV_COND*TIME)	2744.617	32	85.769		
GARMENT * TIME	917.299	12	76.442	.964	.488
Error(GARMENT*TIME)	7609.518	96	79.266		
ENV_COND * GARMENT * TIME	730.796	12	60.900	.979	.475
Error(ENV_COND*GARMENT*TIME)	5973.623	96	62.225		

Seated - Clingy Sensation

Tests of Within-Subjects Effects

Measure: MEASURE_1

Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	21076.446	1	21076.446	56.756	.000
Error(ENV_COND)	2970.821	8	371.353		
GARMENT	10825.786	3	3608.595	4.855	.009
Error(GARMENT)	17839.377	24	743.307		
TIME	14184.779	4	3546.195	18.383	.000
Error(TIME)	6172.870	32	192.902		
ENV_COND * GARMENT	4379.055	3	1459.685	2.826	.060
Error(ENV_COND*GARMENT)	12397.256	24	516.552		
ENV_COND * TIME	4844.287	4	1211.072	12.832	.000
Error(ENV_COND*TIME)	3020.024	32	94.376		
GARMENT * TIME	1926.576	12	160.548	1.725	.073
Error(GARMENT*TIME)	8932.844	96	93.050		
ENV_COND * GARMENT * TIME	887.502	12	73.959	.998	.457
Error(ENV_COND*GARMENT*TIME)	7112.920	96	74.093		

Seated - Scratchy Sensation

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	3038.090	1	3038.090	8.579	.019
Error(ENV_COND)	2833.131	8	354.141		
GARMENT	217179.743	3	72393.248	27.983	.000
Error(GARMENT)	62089.746	24	2587.073		
TIME	2160.037	4	540.009	7.348	.000
Error(TIME)	2351.776	32	73.493		
ENV_COND * GARMENT	5255.716	3	1751.905	4.023	.019
Error(ENV_COND*GARMENT)	10450.453	24	435.436		
ENV_COND * TIME	720.192	4	180.048	2.862	.039
Error(ENV_COND*TIME)	2013.116	32	62.910		
GARMENT * TIME	1800.331	12	150.028	1.823	.055
Error(GARMENT*TIME)	7900.749	96	82.299		
ENV_COND * GARMENT * TIME	1817.270	12	151.439	3.403	.000
Error(ENV_COND*GARMENT*TIME)	4272.120	96	44.501		

Seated - Soft Sensation

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	157.810	1	157.810	.396	.547
Error(ENV_COND)	3186.480	8	398.310		
GARMENT	43332.058	3	14444.019	6.321	.003
Error(GARMENT)	54845.867	24	2285.244		
TIME	105.545	4	26.386	.237	.915
Error(TIME)	3556.560	32	111.143		
ENV_COND * GARMENT	391.653	3	130.551	.174	.913
Error(ENV_COND*GARMENT)	18036.681	24	751.528		
ENV_COND * TIME	260.190	4	65.047	1.093	.376
Error(ENV_COND*TIME)	1903.623	32	59.488		
GARMENT * TIME	2298.852	12	191.571	2.084	.025
Error(GARMENT*TIME)	8824.655	96	91.923		
ENV_COND * GARMENT * TIME	1109.479	12	92.457	.795	.655
Error(ENV_COND*GARMENT*TIME)	11170.796	96	116.362		

Seated - Air Quality (Fresh - Stale)

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	74.442	1	74.442	15.096	.005
Error(ENV_COND)	39.450	8	4.931		
GARMENT	3.072	3	1.024	.813	.499
Error(GARMENT)	30.231	24	1.260		
TIME	2.100	4	.525	2.812	.042
Error(TIME)	5.976	32	.187		
ENV_COND * GARMENT	.479	3	.160	.111	.953
Error(ENV_COND*GARMENT)	34.624	24	1.443		
ENV_COND * TIME	1.005	4	.251	1.722	.169
Error(ENV_COND*TIME)	4.670	32	.146		
GARMENT * TIME	3.793	12	.316	2.429	.008
Error(GARMENT*TIME)	12.493	96	.130		
ENV_COND * GARMENT * TIME	.828	12	6.903E-02	.452	.937
Error(ENV_COND*GARMENT*TIME)	14.658	96	.153		

Seated - Air Quality (Pleasant - Unpleasant)

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	148.858	1	148.858	16.405	.004
Error(ENV_COND)	72.592	8	9.074		
GARMENT	.951	3	.317	.219	.882
Error(GARMENT)	34.719	24	1.447		
TIME	.403	4	.101	.434	.783
Error(TIME)	7.419	32	.232		
ENV_COND * GARMENT	2.468	3	.823	.526	.668
Error(ENV_COND*GARMENT)	37.502	24	1.563		
ENV_COND * TIME	.830	4	.207	1.022	.411
Error(ENV_COND*TIME)	6.492	32	.203		
GARMENT * TIME	2.250	12	.188	1.294	.235
Error(GARMENT*TIME)	13.916	96	.145		
ENV_COND * GARMENT * TIME	3.513	12	.293	1.531	.126
Error(ENV_COND*GARMENT*TIME)	18.353	96	.191		

Seated - Air Temp

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	255.025	1	255.025	311.481	.000
Error(ENV_COND)	6.550	8	.819		
GARMENT	1.031	3	.344	.532	.665
Error(GARMENT)	15.494	24	.646		
TIME	4.711	4	1.178	9.217	.000
Error(TIME)	4.089	32	.128		
ENV_COND * GARMENT	3.164	3	1.055	2.152	.120
Error(ENV_COND*GARMENT)	11.761	24	.490		
ENV_COND * TIME	.156	4	3.889E-02	.396	.810
Error(ENV_COND*TIME)	3.144	32	9.826E-02		
GARMENT * TIME	1.289	12	.107	1.000	.455
Error(GARMENT*TIME)	10.311	96	.107		
ENV_COND * GARMENT * TIME	1.267	12	.106	1.074	.390
Error(ENV_COND*GARMENT*TIME)	9.433	96	9.826E-02		

Seated - Preferred Temp

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	49.878	1	49.878	53.046	.000
Error(ENV_COND)	7.522	8	.940		
GARMENT	2.156	3	.719	1.683	.197
Error(GARMENT)	10.244	24	.427		
TIME	1.017	4	.254	2.270	.083
Error(TIME)	3.583	32	.112		
ENV_COND * GARMENT	2.100	3	.700	2.074	.130
Error(ENV_COND*GARMENT)	8.100	24	.338		
ENV_COND * TIME	.706	4	.176	2.979	.034
Error(ENV_COND*TIME)	1.894	32	5.920E-02		
GARMENT * TIME	.872	12	7.269E-02	1.872	.047
Error(GARMENT*TIME)	3.728	96	3.883E-02		
ENV_COND * GARMENT * TIME	.428	12	3.565E-02	.637	.806
Error(ENV_COND*GARMENT*TIME)	5.372	96	5.596E-02		

Seated - Humidity

Tests of Within-Subjects Effects

Measure: MEASURE_1

Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	166.736	1	166.736	13.360	.006
Error(ENV_COND)	99.839	8	12.480		
GARMENT	7.808	3	2.603	1.317	.292
Error(GARMENT)	47.417	24	1.976		
TIME	.128	4	3.194E-02	.185	.944
Error(TIME)	5.522	32	.173		
ENV_COND * GARMENT	2.053	3	.684	.453	.718
Error(ENV_COND*GARMENT)	36.272	24	1.511		
ENV_COND * TIME	.472	4	.118	1.227	.319
Error(ENV_COND*TIME)	3.078	32	9.618E-02		
GARMENT * TIME	1.094	12	9.120E-02	.671	.775
Error(GARMENT*TIME)	13.056	96	.136		
ENV_COND * GARMENT * TIME	1.906	12	.159	.889	.561
Error(ENV_COND*GARMENT*TIME)	17.144	96	.179		

Seated - Comfort

Tests of Within-Subjects Effects

Measure: MEASURE_1

Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	69298.323	1	69298.323	22.510	.001
Error(ENV_COND)	24627.924	8	3078.490		
GARMENT	103905.048	3	34635.016	8.835	.000
Error(GARMENT)	94089.758	24	3920.407		
TIME	11256.656	4	2814.164	7.006	.000
Error(TIME)	12854.147	32	401.692		
ENV_COND * GARMENT	2397.122	3	799.041	1.645	.205
Error(ENV_COND*GARMENT)	11657.241	24	485.718		
ENV_COND * TIME	4634.618	4	1158.655	3.343	.021
Error(ENV_COND*TIME)	11091.143	32	346.598		
GARMENT * TIME	1891.544	12	157.629	.568	.863
Error(GARMENT*TIME)	26645.853	96	277.561		
ENV_COND * GARMENT * TIME	3980.802	12	331.733	1.535	.125
Error(ENV_COND*GARMENT*TIME)	20747.730	96	216.122		

Seated - Hot/Cold Body Feel

Tests of Within-Subjects Effects

Measure: MEASURE_1

Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	245.633	1	245.633	59.155	.000
Error(ENV_COND)	33.219	8	4.152		
GARMENT	3.586	3	1.195	1.972	.145
Error(GARMENT)	14.546	24	.606		
TIME	77.037	4	19.259	46.966	.000
Error(TIME)	13.122	32	.410		
ENV_COND * GARMENT	.657	3	.219	.230	.874
Error(ENV_COND*GARMENT)	22.819	24	.951		
ENV_COND * TIME	2.262	4	.565	1.455	.239
Error(ENV_COND*TIME)	12.433	32	.389		
GARMENT * TIME	1.121	12	9.343E-02	.552	.874
Error(GARMENT*TIME)	16.236	96	.169		
ENV_COND * GARMENT * TIME	3.953	12	.329	1.344	.207
Error(ENV_COND*GARMENT*TIME)	23.539	96	.245		

Seated - Sweaty Sensation

Tests of Within-Subjects Effects

Measure: MEASURE_1

Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	66912.400	1	66912.400	163.307	.000
Error(ENV_COND)	3277.867	8	409.733		
GARMENT	3980.617	3	1326.872	4.987	.008
Error(GARMENT)	6385.738	24	266.072		
TIME	37680.030	4	9420.007	39.871	.000
Error(TIME)	7560.415	32	236.263		
ENV_COND * GARMENT	1738.958	3	579.653	5.983	.003
Error(ENV_COND*GARMENT)	2325.175	24	96.882		
ENV_COND * TIME	16429.304	4	4107.326	52.607	.000
Error(ENV_COND*TIME)	2498.430	32	78.076		
GARMENT * TIME	1232.840	12	102.737	1.710	.076
Error(GARMENT*TIME)	5768.138	96	60.085		
ENV_COND * GARMENT * TIME	471.437	12	39.286	1.057	.405
Error(ENV_COND*GARMENT*TIME)	3568.652	96	37.173		

Seated - Wet Skin Sensation

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	61674.844	1	61674.844	183.235	.000
Error(ENV_COND)	2692.711	8	336.589		
GARMENT	3905.600	3	1301.867	3.636	.027
Error(GARMENT)	8592.800	24	358.033		
TIME	32739.477	4	8184.869	29.638	.000
Error(TIME)	8837.235	32	276.164		
ENV_COND * GARMENT	1460.642	3	486.881	3.457	.032
Error(ENV_COND*GARMENT)	3379.980	24	140.833		
ENV_COND * TIME	14147.773	4	3536.943	28.354	.000
Error(ENV_COND*TIME)	3991.783	32	124.743		
GARMENT * TIME	1239.585	12	103.299	1.212	.286
Error(GARMENT*TIME)	8182.459	96	85.234		
ENV_COND * GARMENT * TIME	325.432	12	27.119	.565	.865
Error(ENV_COND*GARMENT*TIME)	4604.168	96	47.960		

Seated - Wet/Dry Skin Feel

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	102.656	1	102.656	53.828	.000
Error(ENV_COND)	15.257	8	1.907		
GARMENT	10.585	3	3.528	3.576	.029
Error(GARMENT)	23.681	24	.987		
TIME	93.439	4	23.360	24.745	.000
Error(TIME)	30.208	32	.944		
ENV_COND * GARMENT	.473	3	.158	.169	.916
Error(ENV_COND*GARMENT)	22.410	24	.934		
ENV_COND * TIME	15.671	4	3.918	13.476	.000
Error(ENV_COND*TIME)	9.303	32	.291		
GARMENT * TIME	4.008	12	.334	1.214	.285
Error(GARMENT*TIME)	26.420	96	.275		
ENV_COND * GARMENT * TIME	7.494	12	.625	2.153	.020
Error(ENV_COND*GARMENT*TIME)	27.852	96	.290		

Appendix I
Summary Statistics – Results for Walking Subjects

Walking - Effort Expended

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	1601.325	1	1601.325	24.483	.001
Error(ENV_COND)	523.237	8	65.405		
GARMENT	671.328	3	223.776	2.530	.081
Error(GARMENT)	2122.395	24	88.433		
TIME	627.515	3	209.172	4.179	.016
Error(TIME)	1201.198	24	50.050		
ENV_COND * GARMENT	910.650	3	303.550	2.058	.133
Error(ENV_COND*GARMENT)	3540.777	24	147.532		
ENV_COND * TIME	127.608	3	42.536	2.348	.098
Error(ENV_COND*TIME)	434.787	24	18.116		
GARMENT * TIME	165.203	9	18.356	.976	.467
Error(GARMENT*TIME)	1353.792	72	18.803		
ENV_COND * GARMENT * TIME	118.914	9	13.213	.691	.715
Error(ENV_COND*GARMENT*TIME)	1376.737	72	19.121		

Walking - Comfort

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	64908.986	1	64908.986	21.917	.002
Error(ENV_COND)	23692.955	8	2961.619		
GARMENT	75458.405	3	25152.802	7.886	.001
Error(GARMENT)	76545.097	24	3189.379		
TIME	1138.263	3	379.421	1.619	.211
Error(TIME)	5625.956	24	234.415		
ENV_COND * GARMENT	1029.282	3	343.094	.531	.665
Error(ENV_COND*GARMENT)	15506.724	24	646.113		
ENV_COND * TIME	491.348	3	163.783	1.295	.299
Error(ENV_COND*TIME)	3035.647	24	126.485		
GARMENT * TIME	1961.783	9	217.976	.848	.575
Error(GARMENT*TIME)	18503.338	72	256.991		
ENV_COND * GARMENT * TIME	2517.886	9	279.765	1.228	.292
Error(ENV_COND*GARMENT*TIME)	16409.638	72	227.912		

Walking - Hot/Cold Body Feel

Tests of Within-Subjects Effects

Measure: MEASURE_1

Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	185.714	1	185.714	63.633	.000
Error(ENV_COND)	23.348	8	2.919		
GARMENT	1.848	3	.616	1.413	.263
Error(GARMENT)	10.463	24	.436		
TIME	10.069	3	3.356	8.142	.001
Error(TIME)	9.894	24	.412		
ENV_COND * GARMENT	1.076	3	.359	.620	.609
Error(ENV_COND*GARMENT)	13.879	24	.578		
ENV_COND * TIME	2.386	3	.795	2.372	.095
Error(ENV_COND*TIME)	8.047	24	.335		
GARMENT * TIME	1.048	9	.116	.754	.659
Error(GARMENT*TIME)	11.127	72	.155		
ENV_COND * GARMENT * TIME	2.320	9	.258	1.581	.137
Error(ENV_COND*GARMENT*TIME)	11.740	72	.163		

Walking - Wet/Dry Skin Feel

Tests of Within-Subjects Effects

Measure: MEASURE_1

Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	105.117	1	105.117	82.258	.000
Error(ENV_COND)	10.223	8	1.278		
GARMENT	4.479	3	1.493	1.895	.157
Error(GARMENT)	18.913	24	.788		
TIME	11.527	3	3.842	12.314	.000
Error(TIME)	7.489	24	.312		
ENV_COND * GARMENT	3.867	3	1.289	2.756	.064
Error(ENV_COND*GARMENT)	11.228	24	.468		
ENV_COND * TIME	.245	3	8.154E-02	.403	.752
Error(ENV_COND*TIME)	4.853	24	.202		
GARMENT * TIME	.420	9	4.663E-02	.234	.988
Error(GARMENT*TIME)	14.334	72	.199		
ENV_COND * GARMENT * TIME	2.497	9	.277	1.290	.258
Error(ENV_COND*GARMENT*TIME)	15.489	72	.215		

Walking - Clothing/Skin Contact Sensation

Tests of Within-Subjects Effects

Measure: MEASURE_1
Sphericity Assumed

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
ENV_COND	136.684	1	136.684	34.813	.000
Error(ENV_COND)	31.410	8	3.926		
GARMENT	51.057	3	17.019	5.309	.006
Error(GARMENT)	76.932	24	3.206		
TIME	12.799	3	4.266	10.913	.000
Error(TIME)	9.383	24	.391		
ENV_COND * GARMENT	2.970	3	.990	.433	.731
Error(ENV_COND*GARMENT)	54.868	24	2.286		
ENV_COND * TIME	3.312	3	1.104	6.816	.002
Error(ENV_COND*TIME)	3.887	24	.162		
GARMENT * TIME	5.111	9	.568	1.465	.177
Error(GARMENT*TIME)	27.902	72	.388		
ENV_COND * GARMENT * TIME	2.165	9	.241	.784	.632
Error(ENV_COND*GARMENT*TIME)	22.097	72	.307		